OW Combined Summary of Ecological Impacts of the oil Spill

These initial evaluations are highly speculative and based on best professional judgment. They will be refined as more specific information is received. In the face of considerable uncertainty about the present and future quantities of oil released, the actual make up of the oil, its anticipated trajectory of impact, the effect of projected use of deep water dispersants, future meteorological conditions and other aspects of the situation, outcomes anticipated in this document could change dramatically as new data become available.

Information was synthesized and gathered from:

- EPA Region 6 - Speculations on Potential Impacts from the Deepwater Horizon Oil Release Deep Water Horizon Incident
- EPA Region 4 - Speculations on Potential Impacts from the Deepwater Horizon Incident MMS EIS (Ch.4) and 3-26 Risk Analysis of Oil Spill (Gulf of Mexico OCS Oil and Gas Lease Sales: 2009-2012 Central Planning Area Sales 208, 213, 216, and 222 Western Planning Area Sales 210, 215, and 218; http://www.mms.gov/5-year/2007-2012FEIS.htm)
- OW Human Health and Ecological Impacts Team
- Consideration Regarding the Deepwater Dispersion
- NOAA: http://www.st.nmfs.noaa.gov/st1/index.html

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1. Results from analysis of Deepwater Horizon sample

After reviewing the analytical data from analysis of the Deepwater Horizon sample, several conclusions can be initially drawn. This is an unusual type of oil spill. The oil is very light and only contains low levels of aromatics and sulfur components (sweet crude), yet it does contain very high levels of asphaltenes. This means the following:

1) the light components will quickly evaporate (weather) leaving behind a tary asphaltene residue with near zero odor (no volatiles)
2) this residue will form to some extent "water in oil" emulsions with sea state agitation
3) after initial loss due to evaporation, the tary residue will not further degrade extensively
4) with little aromatic composition, the conventional environmental toxicity will be very limited
5) the water soluble fraction (aromatic components) in near shore environments will be minimal (no conventional toxicity)
6) microbial degradation of the tary residue will be difficult and very slow (asphalt roads don't degrade)
7) the tary residue will be difficult to burn
8) the tary residue will be very sticky, and nearly neutrally buoyant
9) the tary residue will not disperse very easily
10) the tary residue will coat everything when it get ashore, and be difficult to clean up
11) most of the impacts will be from the coating and stickiness of the residue
12) some residue could pick up sediments, become heavy and sink

The above assumptions should be considered as a "heads up" for how to handle this very unusual spill situation. Many of the conventional cleanup options may not be effective. While not toxic in the conventional sense, the stickiness of this residue will have significant shoreline impacts along Louisiana's marshes and the beaches in the panhandle.

2. General Ecological Considerations

Because the oil is being released such a distance from shore and at such depth, it is anticipated that the oil will undergo significant weathering before reaching shoreline areas. Sea conditions will weather the oil, as the more water soluble compounds tend to be "extracted" from the oil, leaving the less soluble and more viscous compounds to continue to coalesce on the water surface. The use of dispersants offshore will lessen the potential impact of the oil onshore, however it may increase the risk for water column toxicity in the areas where the dispersants are being used. Generally, dispersants are used in deeper waters, which allow aquatic life the opportunity to flee from the plume of dispersed compounds. Using dispersants in shallow water can exacerbate some of the aquatic toxicity of the spilled oil (e.g., it solubilizes chemicals contained in the oil) and therefore they are not often recommended for use in shallow waters.

The immediate impacts of the oil release are to the open ocean and to the intertidal zone and marshes of the Pass A Loutre Wildlife Management Area and the Delta National Wildlife Area in the eastern portion of the Mississippi River Delta of Louisiana. Next in the pathway appear to be the Chandeleur Islands within the Breton National Wildlife Refuge, Breton Sound, Chandeleur Sound, and the highly fragmented marshes of Plaquemines and St. Bernard Parishes.

The Mississippi River Gulf Outlet could offer oil ingress to additional expanses of those marsh habitats. Once in Breton Sound, oil could move into Mississippi Sound and onto western Mississippi barrier islands and shorelines. Oil could also move in a westerly direction into Lake Borgne and Lake Pontchartrain, due to the broken marsh topography, expanse of open water, and meteorological influences.

The areas most likely to be impacted in the short-term include Regions 1 and 2 of the Louisiana Regional Restoration Planning Program (see below & EPA Region 6 - Speculations on Potential Impacts from the Deepwater Horizon Oil Release Deep Water Horizon Incident, Appendix A).

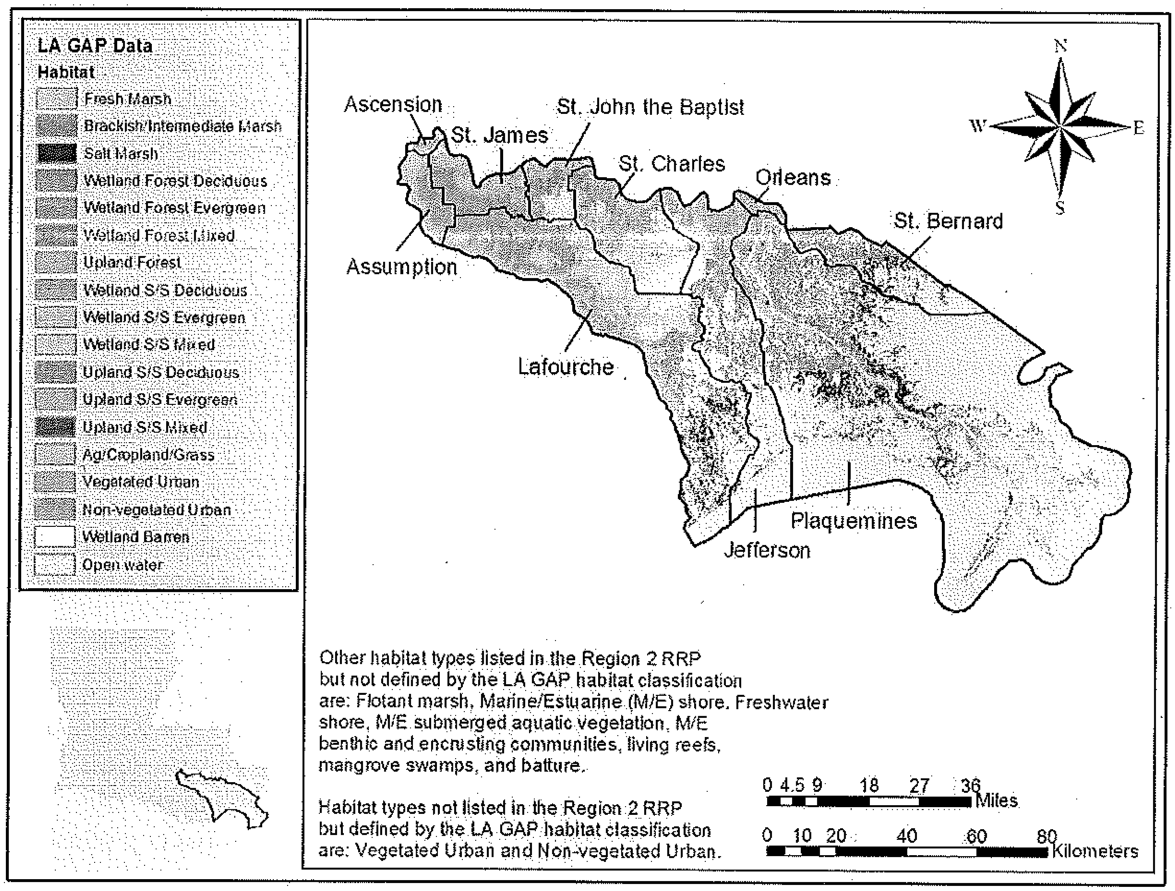


Figure 2: Region 2 Boundary, Parishes, and Associated Habitat Types (adapted from Hartley et al. 2000)

The eastern margins of the Louisiana deltaic wetlands are even more susceptible to these influences than that of the west, because they are low-lying and formed from the Mississippi sediment deposition. It is here that the Deepwater Horizon oil spill will most likely come ashore and there is no worse place. The 500,000 acres of wetlands at risk are some of the most valuable of the irreplaceable, and they are already reeling from the one - two punch of long time abuse and natural disaster. While it seems impossible to put value on something that is priceless, it is a way of putting the loss, and potential loss, into some frame of reference that we can begin to understand.

Ocean and meteorological conditions could change, driving oil to any and all Gulf coastal states. The official start of the Atlantic hurricane season is a month away and a tropical storm could spread the oil throughout a wide area of the Gulf.

In general, the released oil could have the following effects on marine life: direct mortality, reduced fitness as a result of sublethal effects, and disruption of the structure and function of marine communities and ecosystems (NRC, 2003 Oil on the Sea III: Inputs, Fates, and Effects, National Research Council, 2003., (pg.120))

The toxicity of petroleum to marine organisms is dependent upon the concentration and composition of the hydrocarbons at the time of impact. The ecological effects of the oil will shift as the spilled oil weathers and the chemical composition changes. The specific biological and chemical effects will change over time and the cumulative impacts may trigger additional ecological response mechanisms.

Considering the potential area that could be impacted by the Deepwater Horizon spill, as much as $1.6 billion of annual economic activity and services are at risk. This estimate includes ecosystem services of $1.2 billion; recreational fishing ($114 million), commercial fishing ($30.3 million) and tourism ($77.6 million). Realized losses cannot be determined until we know the extent of spill impact.

Dr. David Yoskowitz, the endowed chair for Socio-Economics at the Harte Research Institute for the Gulf of Mexico Studies, and a leading expert on the valuation of ecosystem services in the Gulf of Mexico, is trying to do just that. What he can calculate right now is just the tip of the iceberg, he says and his estimate is very conservative at this point.

The most fundamental building block, the foundation, of the Gulf ecosystem based enterprise is the wetlands and the services they provide. The ecosystem services* provided by the Gulf coastal wetlands are undervalued and under-appreciated. These services affect human and ecosystem well-being and they are compromised by both natural and human impacts. Focusing on only two prominent services of coastal wetlands (storm protection and waste treatment) and utilizing the HRI valuation database, Dr. Yoskowitz has estimated a very conservative $2,400 per acre impact on ecosystem services for the Louisiana-Mississippi-Alabama gulf coast region per year. This translates to over $1.2 billion in lost services for 500,000 acres of impacted marsh, which represents only 15% of Louisiana's coastal wetlands. Depending on how long it takes for recovery, if recovery is possible, the losses are compounded. Everyone hopes the impacts will be significantly smaller in scale than used in this example. Regardless this value is only the tip of a very large iceberg. This figure does not begin to take into account the economic impact that will be felt down the "supply chain" as a result of damaged wetlands. (**Definition of ecosystem services: Ecosystem services are the direct or indirect contributions that the environment makes to the well-being of the human population.)*

Fish processors, distributors, restaurants, and the employees of all of them will feel the negative effects. Tour operators and guides will also be caught up in the compounding impact. Additionally there are a number of other habitats that will be impacted such as oyster reefs, open bay bottom, and beaches that will only add to the direct and indirect economic impact of this oil spill.

3. Offshore

Physical Impacts to the Environment

A thick sheet of oil over a large surface area of the ocean cuts off the oxygen exchange with the water column, resulting in low dissolved oxygen. Fish respond by coming to the surface to for oxygen and their gills may become coated with oil, resulting in mortality. Low dissolved oxygen below the surface can also result in mortality to shrimp, crabs, oysters and sessile invertebrates. This should be considered a very worst case scenario and is not likely to happen in the open ocean. Though true for fishes and invertebrates coming into direct contact with oil at the surface, these will mainly be those communities that live directly on or very near the surface; most do not.

Summer is the season that the Gulf of Mexico hypoxic zone sets up, generally flowing westward from the Mississippi River plume. The phenomenon results in low dissolved oxygen in bottom waters. Coastal currents generally flow westward during winter/spring, but reverse during late spring and summer and flow eastward. Decaying wetland plant material from oil contamination to submerged aquatic vegetation, intertidal areas behind barrier islands and along headlands, and marshes may be released into the bays and coastal ocean. The organic materials and oxygen demand may contribute to localized instances of hypoxia as well as to the wider Gulf hypoxic zone along the continental shelf.

Weathering processes will cause the offshore oil to become more dense over time and more will settle to the seafloor. It is possible that impacts to ground fishes and benthic invertebrates in both soft bottom and hard bottom habitats may occur. That could include hypoxia conditions as the oil itself will degrade and create oxygen demand and both acute and chronic impacts due to oil contamination of the benthic sediments.

Chemical Impacts to the Environment

The toxicity of petroleum on marine organisms is dependent upon the concentration and composition of its individual hydrocarbons at the time of impact. The relative impact of the oil will shift as spilled oil weathers due to the change in its chemical composition.

The portion of the oil that dissolves, the water soluble fraction (WSF), appears to be the most highly toxic to organisms, possibly due to the rapid uptake of oil in this form. Water-in-oil emulsions of spilled oil are likely to cause biological damage due to physical effects, while oil-in-water emulsions probably cause more biological damage due to toxics effects.

Biological Impacts and Processes

The toxicity of petroleum to marine organisms is dependent upon the concentration and composition of the hydrocarbons at the time of impact. The ecological effects of the oil will shift as the spilled oil weathers and the chemical composition changes. The specific biological and chemical effects will change over time and the cumulative impacts may trigger additional ecological response mechanisms.

Biological processes include biodegradation and ingestion by zooplankton and higher forms of marine organisms including crustacea and fish. The order of rates of biological degradation from petroleum is: alkanes>isoalkanes>cycloalkanes>aromatics. The rate of decomposition is dependent on the nature and abundance of the indigenous microbial assemblage, the available inorganic nutrients and oxygen, and the ambient temperature.

Biological processes will likely drive the ultimate fate of deeply dispersed oil. These may include: (a) Degradation of petroleum hydrocarbons by oil-degrading microorganisms, and (b) Consumption of small oil droplets by plankton and other particle-feeding organisms.

Oxygen is required for microbes to degrade oil. Fortunately there is sufficient oxygen (3-4 ppm) in these waters. However, biodegradation is slower at cold temperatures. So what may take days in warm surface water may take weeks in deep cold water.

Dependence of the deep-sea food web on organic carbon from the sea surface suggests that the ecosystem may be able to accommodate or process oil droplets provided they have lost their toxic compounds such as monocyclic aromatics and naphthalenes.

In the past, biological oceanographers have observed plankton consuming oil particles in the upper ocean layer. They produce oil-contaminated fecal pellets, which can settle to the bottom mush faster than unconsumed oil droplets. There are fewer plankton at depth and we do not know if they too would consume the droplets.

The most immediate affect in the offshore waters is that the oil would come in contact with the microscopic plankton (which are tiny plants, known as phytoplankton, fish eggs and larvae, and other small animals) in the surface waters, and fish, turtles, and marine mammals.

Short-term effects of oil spillage resulting in biological loss occurs by direct kill through coating and asphyxiation, by contact poisoning or incorporation of water-soluble toxic carcinogens or mutagenic components of oil, by destruction of the generally more sensitive juvenile forms of organisms or of the food source of higher trophic species, and by modification of habitats, delaying or preventing decolonization (Blumer, 1971).

The phytoplankton form the base of the food web that supports marine species. Any impacts on this food base may affect the entire marine ecosystem. Phytoplankton and zooplankton, critical components to the marine ecosystem, have demonstrated different reactions to oil (Wong et al., 1981: Gordon and Prouse, 1973; NAS, 1975; and Casey et al., 1982). The impact on the phytoplankton will depend on how long the oil persists as they have short life spans, new phytoplankton can be recruited from other areas, and they move up and down the water column, thus, limiting their exposure. Larvae stages of the fish life cycle are more susceptible to acute toxic effects. Fish eggs and larvae are more vulnerable to oil damage in the open water environment as they float along (NAS, 1975).

Small animals such as lantern fish, amphipods, jellies, invertebrate eggs and larvae, may be entrained in the plume as it expands and is transported by the currents. Depending on where these animals are entrained, they will experience an initial or high peak oil concentration and then declining concentrations as the plume expands in 3 dimensions. Such exposure may be longterm (days, weeks)

Larger pelagic animals such as medium-sized fish and squids, may swim into the plumes and back out again. We have no idea whether they are able to detect and avoid the dispersed oil, nor how long they can tolerate exposure without being debilitated. Such exposure may be relatively short.

Bottom dwelling organisms including several species of colony forming corals and knoll-top chemosynthetic methane-seep communities could be exposed to dispersed oil plumes that "touch bottom" or move across projecting natural structures. The currents that bring this oil in may change, exposing the biota to clean water. Thus such exposure may be long or short depending on the currents and concentrations.

A considerable amount of information exists for evaluating the effects of dispersants and dispersed oil on surface dwelling marine life and plants and estuarine plants and animals. Dispersed oil is toxic to surface dwelling marine life at concentrations in the range of 0.1 to 10 or more parts per million with exposures lasting up to 4 days. Eggs and larvae are much more sensitive to dispersed oil toxicity than are adult animals. There is no data on the toxicity of dispersed oil to deep-sea biota at any life stage, so we have to extrapolate the best we can. One way is to focus on information on cold-water (arctic) species.

Fisheries

Commercial fisheries would be affected by oil spills in several ways. The possibility of oil-soaked fishing gear and potentially contaminated fish may reduce commercial fishing efforts or may affect the value of catches, resulting in economic loss. Individuals of target fish species could be affected directly by exposure to spilled oil. Hydrocarbons from spilled oil can affect adult fishes by direct contact with gills or deposition in the gut after swallowing spilled oil. Toxic fractions of PAH's in spilled oil can cause death or illness in adult fishes, but only with continuous exposure. Adult and juvenile fishes typically are capable of avoiding large spills by moving to other areas or deeper water. However, planktonic eggs, larvae, and neustonic communities would be unable to avoid spilled oil. Eggs and larvae of fishes would die if exposed to certain toxic fractions of spilled oil. Most of the fish species inhabiting shelf or oceanic waters of the Gulf of Mexico have planktonic eggs and larvae (Ditty 1986; Ditty et al. 1988, Richards and Potthoff 1980; Richards et al. 1993). Certain species, such as triggerfishes, deposit demersal eggs but have larvae that take up residence in the water column, so these species would also be affected. Effects would be potentially greater if local water currents retained planktonic larvae and floating oil within the same water mass for extended periods of time. However, this would depend on the location and timing of particular spills.

Oil spills could also result in interference with fishing operations, loss of use of traditional fishing areas, tainting of catches, and fouling of gear (Bolger et al. 1996; Hom et al. 1996). The resulting effect to individual fishers could be short-term loss of income and, at worst, loss of livelihood in a particular region.

Many fish and shellfish species in Gulf of Mexico are fished commercially. Shrimps are taken by bottom trawling, menhaden are caught in purse nets, yellowfin tuna are caught on surface longlines, and snapper and grouper are caught by hook and line; pots and traps are used for crab, spiny lobster and some fish species.

Two penaeid shrimp species (i.e., brown and white) were the most valuable species landed in 2002. In terms of pounds landed in 2002, menhaden, a small coastal pelagic species, contributed the highest proportion (74.5%) of the landings. Shrimps and blue crab were also important, collectively representing about 17 percent of the total 2002 landings by weight.

The commercial fish and shellfish harvest from the five U.S. Gulf states was estimated to be 1.3 billion pounds and valued at $661 million. Louisiana wetlands account for 21 percent of landings for all 48 states and exceed $202,000,000 annually. Economic impact of recreational fishing in Louisiana exceeds $757 million annually and creates 7,733 jobs. The stakes are huge for the thousands of commercial fishermen, recreational guides and members of the tourism industry dependent on these wetlands. Wildlife-viewing alone generates over $517,000,000, annually. This is saying nothing about the people dependent on them, like fish and oyster processing houses, hotels, boat dealers, etc.

In 2002, commercial fishery landings in the Gulf of Mexico, which includes western Florida, Alabama, Mississippi, Louisiana, and Texas, exceeded 782,000 metric tons (t), worth over $704 million (NMFS, 2002). Of the individual States, Louisiana led in total landings and value in 2002 with 591,839 t landed, worth $306 million. Mississippi was second with landings exceeding 98,869 t, worth $47 million, followed by Texas (42,211 t, $173 million), Florida's west coast (37,072 t, $144 million), and Alabama (10,702 t, $36 million). The commercial fisheries landings of the Central Gulf Coast may be drastically impacted by the oil spill this year.

NMFS Landings Query Results

You Asked For the Following:

- Year : From: 2008 To: 2008
- Species : Shrimp
- State : Gulf

Year	Species	Metric Tons	Pounds	$
2008	SHRIMP, BROWN	35,864.4	79,066,734	141,719,646
2008	SHRIMP, DENDROBRANCHIATA	1,045.6	2,305,084	9,701,184

2008	SHRIMP, MARINE, OTHER	79.9	176,246	600,733
2008	SHRIMP, PINK	3,207.4	7,071,033	13,193,378
2008	SHRIMP, ROCK	146.3	322,606	517,700
2008	SHRIMP, ROYAL RED	96.9	213,678	671,427
2008	SHRIMP, SEABOB	605.0	1,333,791	535,519
2008	SHRIMP, WHITE	44,586.3	98,294,953	199,627,196
GRAND TOTALS:	-	85,631.9	188,784,125	366,566,783

According to Evans and Rice (1974), the impacts on fishery resources from oil pollution are: (a) killing organisms through coating and asphyxiation; (b) killing organisms through contact poisoning; (c) killing organisms though exposure to water soluble toxic components of oil at some distance in time and space from the accident; (d) destroying the generally more sensitive juvenile organisms; (e) destroying sources of food and shelter; (f) incorporating sublethal amounts of oil and oil products into organisms (resulting in reduced resistance to infection and other stresses); (g) incorporating carcinogenic and potentially mutagenic chemicals into marine organisms; and

Fish can be impacted directly through uptake by the gills, ingestion of oil or oiled prey, effects on eggs and larval survival, or changes in the ecosystem that support the fish. Adult fish may experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion, and reproductive impairment when exposed to oil. Oil has the potential to impact spawning success, as eggs and larvae of many fish species, are highly sensitive to the toxic constituents of crude oil.

Eggs and larvae of marine organisms, such as tuna and squid, float at or very near the surface of the ocean. If the floating oil, dispersed oil, or chemical dispersants were to encounter masses of these eggs and/or larvae, potentially significant impacts to Gulf populations of these organisms could result, at least for the current year class.

A significant impact will be on the blue fin tuna as they are currently breeding and, therefore, the potential for population impacts is possible. The Gulf of Mexico is the only spawning ground of the western Atlantic population of the blue fin tuna, which is at the peak of breeding season. Spawning in the Gulf of Mexico occurs from April to June. Differences in timing could be due to any of a number of factors, such as differing environmental cues or genetic variation. In the Gulf of Mexico, spawning occurs at temperatures of 76.8 to 85.1 °F(24.9 to 29.5 °C). Average females produce up to 10 million eggs per year. Their eggs are buoyant, and are distributed a considerable distance by the surface currents. Since they have buoyant eggs, this may be an issue depending on where the spawning pods are and where the oil slick is. Both chemical toxicity and physical smothering of eggs and icthyoplankton (larval fish) may occur. This type of impact is also a concern for other tuna species and other pelagic fish with this reproductive strategy. As of May 2, 2010, NOAA has restricted fishing for a minimum of ten days in federal waters most affected by the oil release, largely between Louisiana state waters at the mouth of the Mississippi River to waters off Florida's Pensacola Bay. The closure is effective immediately. Details can be found here: http://sero.nmfs.noaa.gov/.

Marine Mammals

Twenty-nine species of marine mammals occur in the open Gulf of Mexico (Davis et al., 2000) and some may be found in the associated bays and inlets (bottlenose dolphins and manatees). The Gulf of Mexico's marine mammals are represented by members of the taxonomic order Cetacea, which is divided into the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales), as well as the order Sirenia, which includes the manatee and dugong. Within the Gulf of Mexico, there are 28 species of cetaceans (7 mysticete and 21 odontocete species) and 1 sirenian species, the manatee.

Sperm whales are at much more risk at the surface (from inhalation of volatiles and direct contact with slicks) than they would be from diving through dispersed oil in deep water or consuming squid that may be exposed to deep water dispersed oil plumes.

For cetaceans (and probably sirenians as well), direct contact of oil may irritate, inflame, or damage skin and sensitive tissues (such as eyes and other mucous membranes) (Geraci and St. Aubin, 1982). Prolonged contact to petroleum products may reduce food intake; elicit agitated behavior; alter blood parameters, respiration rates, and gas exchange; and depress nervous functions (Lukina et al., 1996).

Fresh crude oil releases toxic vapors that when inhaled may irritate or damage respiratory membranes, congest lungs, and cause pneumonia. Following inhalation, volatile hydrocarbons may be absorbed into the bloodstream and accumulate in the brain and liver, leading to neurological disorders and liver damage (Geraci and St. Aubin, 1982; Geraci, 1990). Toxic vapor concentrations may occur just above the surface of an oil spill and, thus, may be available for inhalation by surfacing cetaceans.

Marine mammals may incidentally ingest floating or submerged oil or tar and may consume oil-contaminated prey (Geraci, 1990). Spilled oil may also foul the baleen fibers of mysticete whales, temporarily impairing food-gathering efficiency or resulting in the ingestion of oil or oil-contaminated prey (Geraci and St. Aubin, 1987). Ingested oil can remain within the gastrointestinal tract and be absorbed into the bloodstream and, thus, could irritate and/or destroy epithelial cells in the stomach and intestine. Certain constituents of oil, such as aromatic hydrocarbons and polyaromatic hydrocarbons, include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms.

Marine and Coastal Birds

These coastal areas are home of the two largest flyways for migratory waterfowl and songbirds which depend upon the ecosystem services of these coastal wetlands as they travel seasonally between North and South America. There are four groups of birds that inhabit the Gulf of

Mexico region for at least some portion of their life cycle. These groups include: seabirds, shorebirds, wetland birds, and waterfowl.

Exposure to spills in deep water would be largely limited to pelagic birds (unless the spill goes ashore). Adult and young birds may come in direct contact with oil on the water's surface. Birds may ingest oil incidentally while foraging and while preening oiled feathers. Certain species of marine and coastal birds may be more susceptible to contact with spilled oil than others, based on their life histories. For example, diving birds and underwater swimmers such as loons, cormorants, and diving ducks may be the most susceptible to spilled oil because of their relatively long exposure time in the water and at the sea surface.

Marine birds which spend much time on the sea surface (e.g. shearwaters, cormorants, seaducks, and alcids) are especially vulnerable to oil spills (King and Sanger, 1979). Mortality results primarily from hypothermia as oil mats the plumage destroying the thermal barrier. Direct contact by birds with oil of appreciable amounts is usually fatal. Abnormalities in bird reproduction physiology and behavior resulting from ingestion of oil potentially could have substantial adverse effects on egg production in seabird and water fowl populations.

Threatened or Endangered Species

Marine Mammals

Five baleen whales (the northern right, blue, fin, sei, and humpback), one toothed whale (the sperm whale), and one sirenian (the West Indian manatee) occur in the Gulf of Mexico and are listed as endangered under the Endangered Species Act (ESA). The sperm whale is common in oceanic waters of the northern Gulf of Mexico and may be a resident species, while the baleen whales are considered rare or extralimital in the Gulf (Würsig et al., 2000).

Gulf Sturgeon

After a review by NOAA in 2003, critical habitat for Gulf sturgeon (Acipenser oxiyrinchus desotoi) was designated in a final rulemaking (68 FR 13370-13495, 2003). The Gulf sturgeon is an anadromous fish that migrates from the sea upstream into coastal rivers to spawn in freshwater. Thus, depending on migratory season, the Gulf sturgeon may be vulnerable to the impacts of oil (See Onshore Threatened and Endangered Species section for more information on impacts).

Turtles

Five species of sea turtles, the green, hawksbill, Kemp's ridley, leatherback, and loggerhead, are known to inhabit the Gulf of Mexico (Table III-8) (Pritchard, 1997). All five are listed as either endangered or threatened species under the ESA (Pritchard, 1997). The life history of sea turtles includes four developmental stages: embryo, hatchling, juvenile, and adult. Sea turtle eggs deposited in excavated nests on sandy beaches are especially vulnerable to oil impacts. After hatching and swimming offshore, hatchling turtles move immediately from these nests to the sea. Most species ultimately move into areas of current convergence or to mats of floating Sargassum, where they undergo primarily passive migration within oceanic gyre systems (Carr and Meylan, 1980). The passive nature of hatchling turtles, along with their small size, makes them vulnerable in open-ocean environments.

There are reports of recent nesting in Alabama (loggerhead and green turtles) along Dauphin Island and the Gulf Islands National Seashore; Mississippi (loggerhead turtles) along the Gulf Islands National Seashore; and Louisiana (loggerhead turtles) within the Breton National Wildlife Refuge. Sea turtles also nest along areas of the Texas coast (Padre Island National Seashore), including loggerhead, green, and Kemp's ridley turtles (S. MacPherson, FWS, pers. commun., 2000). There are no designated critical habitats or migratory routes for sea turtles in the northern Gulf of Mexico. The NMFS does recognize many coastal areas of the Gulf as preferred habitat (i.e., important sensitive habitats that are essential for the species within a specific geographic area), for example, seagrass beds in Texas lagoons and other nearshore or inshore areas (including jetties) for green turtles, and bays and lakes, especially in Louisiana and Texas, for ridleys. Sargassum mats are also recognized as preferred habitat for hatchlings (Carr and Meylan, 1980).

Offshore oil spills could also have a serious impact on juvenile turtles. Because hatchlings spend more time at the sea surface, they will be more likely to be exposed to surface oil slicks than adults or juveniles. Some evidence indicates that sea turtles, especially juveniles, are transported by passive drift and are associated with sargassum (marine brown algae) mats where oceanic currents converge. This could prolong their exposure to a large oil slick transported in the same manner. Sea turtles and marine mammals must surface to breathe and could contact surface oil slicks.

Sea turtles surfacing and diving in an oil spill may inhale petroleum vapors and aspirate small quantities of oil. While no information is available regarding the effects of petroleum vapors or aspirated oil on sea turtles, inhalations by mammals of small amounts of oil or petroleum vapors have been shown to result in acute fatal pneumonia, absorption of hydrocarbons in organs and other tissues, and damage to the brain and central nervous system.

Ingested oil, particularly the lighter fractions, could be toxic to sea turtles. Ingested oil may remain within the gastrointestinal tract, irritate and/or destroy epithelial cells in the stomach and intestine, and subsequently be absorbed into the bloodstream (NOAA, 2003). Certain constituents of oil, such as aromatic hydrocarbons and PAHs, include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms. Hatchling and juvenile turtles feed opportunistically at or near the surface in oceanic waters, and may be especially vulnerable and sensitive to spilled oil and oil residues such as floating tar (Lutz and Lutcavage, 1987; Lutcavage et al., 1995). Tar found in the mouths of turtles may have been selectively eaten or ingested accidentally while feeding on organisms or vegetation bound by tar (Geraci and St. Aubin, 1987; Geraci, 1990). Sea turtles exposed to oil or tar balls have been reported to incur a variety of conditions, including inflammatory dermatitis, breathing disturbance, salt gland dysfunction or failure, hematological disturbances, impaired immune responses, and digestive disorders or blockages (Vargo et al., 1986; Lutz and Lutcavage, 1989). Ingested tar may also result in starvation from gut blockage and decreased food adsorption efficiency, absorption of toxins, local necrosis or ulceration associated with gut blockage, interference with fat metabolism, and buoyancy problems (NOAA, 2003).

Certain species of sea turtles may be at greater potential risk of exposure to spilled oil based on their distributions and habitat preferences and also on the timing of a spill. For example, loggerhead and Kemp's ridley sea turtles frequent current-restricted areas such as bays and estuaries. Because oil entering these areas may remain for longer periods of time due to reduced weathering rates and natural dispersion, sea turtles utilizing habitats in these areas may incur longer exposure periods. Spills occurring in coastal waters of Texas may affect greater numbers of green, hawksbill, loggerhead, and leatherback sea turtles during summer months when nearshore densities are greater than offshore densities.

4. Onshore

There are a number of sensitive coastal habitats and shorelines along the Gulf of Mexico coast. Appendix B describes these coastal areas as to their sensitivity and the behavior of oil and cleanup considerations in these areas.

Physical Impacts to the Environment

Southern Louisiana contains 40% of the wetlands found in the lower 48 states. The seafood production from the Gulf of Mexico exceeds that of all the areas of the east coast from Maine to Florida, combined. Louisiana accounts for almost 80% of that Gulf production. Recreational fishing pumps billions of dollars into regional economies each year (Louisiana - $757 million). All of that bounty depends on a healthy functioning wetland ecosystem. It is a wetland complex that not only produces seafood but one that provides natural filtration, cleaning water of pollution and contaminants. That service alone saves us millions of dollars in annual treatment costs and allows us live by the sea and not a sewage pond. It is a wetland that protects our coastal communities from natural disasters. Every mile of wetlands can reduce storm surge by as much as a foot. That means billions saved in lost property, not to mention lives. All these valuable contributions to our health and well being are at risk as never before because of long abuse, capped by what could be one of the most significant oil spills ever in our coastal waters.

Perhaps no place on earth is disappearing as rapidly as the Louisiana coast. The Mississippi deltaic plain is experiencing some of the highest historic rates of coastal wetland loss in the country and in the world. Coastal wetland loss has been widespread in Louisiana over the past century and an historic average of 25-30 square miles of land was lost per year from 1978-2000 (Barras *et al.* 2003). Current trends point to an additional loss of approximately 1300 km^2 by 2050. This region experienced yet another spike in wetland loss and degradation as a result of major hurricanes over the last few years. However, the vast expanse of the existing productive wetland ecosystem still represents a significant regional and national asset. Any additional stress from the Deepwater Horizon oil release could be devastating to these resources and serve as a tipping point to the sustainability of the coastal landscape as we know it. The ecological and associated economic impacts could easily have national ramifications.

Although much of the Mississippi delta coastal area is extraordinarily vulnerable, one of the areas seemingly in the path of the oil slick stands out. The Chandeleur Islands historically provided important breeding areas for colonial seabirds including brown pelican, sandwich terns, royal terns, and black skimmers, and was an important wintering area for redheads. The area supported a large and diverse barrier island community of beaches, vegetated dunes, overwash fans, back barrier brackish/saline emergent tidal marsh, and seagrasses prior to the passage of Hurricane Katrina. Hurricane Katrina reduced the land area approximately 80% and reduced elevation and vegetated cover. Remaining island remnants are subject to accelerated erosion from tides and wave fetch and the future of this area is uncertain.

The Deepwater Horizon oil release in the Gulf of Mexico not only represents another insult to a declining and fragile ecosystems but could have direct impacts on land loss if it causes significant plant mortality. If the plants are lost, the land washes away.

Wetlands are fairly fragile and very biologically active habitats, therefore the physical effects of fouling and coating of these environments are expected to be significant. It is very difficult to clean wetlands once they have been oiled. The options for cleaning the wetlands depend on a variety of factors. If the oil reaches beyond the grassy vegetation and gets to the sediments, however, options are very limited. Digging up the wetlands to remove the oil can oftentimes cause more harm than leaving the oil in place. Natural processes such as wave action to remove the oil are often not very effective, because the wetlands are usually in fairly quiescent areas which limit the amount of wave action. It should be noted that heavily oiled sea grass beds may die immediately upon contact with the oil and entire intertidal beds of sea grasses may be killed. Subtidal sea grasses could be spared, although leaves may turn brown and become heavily covered by algae for several months. This type of impact was seen following the spill in Panama.

Oil spills are more damaging to intertidal and salt marshes during the spring growing season. "When high levels of crude and heavy fuel oils accumulate in the sediments or remain within the marsh for long periods, the result is complete death of large areas of smooth cordgrass." (NRC, 2003, Oil on the Sea III: Inputs, Fates, and Effects, National Research Council, 2003., (pg.143)).

The goal should be to minimize damage to coastal wetland habitats from the cleanup effort itself. Too many people and machines mucking about could seriously compound the damage. The rule of thumb should be to place top priority on maintaining the physical and chemical integrity of the habitat, so the organisms will have an opportunity to repopulate. Treat the marshes gently.

Marsh plants may survive being oiled, unless the majority of the plant is covered, including roots and stems. If incident response personnel are walking or moving equipment throughout the marshes, compacting the substrate and uprooting plants, holes could open up where open water could replace marsh. To the degree possible, it would be advantageous to restrict response vehicles, equipment, and personnel to established waterways and to minimize boat wakes. People and boats moving about in shallow, soft substrates or in deltaic marshes built largely on organic mucks could prove to be another source of ecological injury.

It is anticipated that because the oil will likely be somewhat weathered if it were to reach a wetland, the relatively thick oil would cause physical smothering of the sediments, sediment dwelling organisms including eggs that have been laid, and the wetland plants. Again, some chemical toxicity would be expected, but the main effect would likely be a physical smothering. This physical smothering and coating effect would be both for the plants and aquatic/semi-aquatic animals, as well as for any animals such as birds or mammals that come into contact with the oil in the marshes.

It is also anticipated that over time, natural attenuation processes such as microbial degradation would work to degrade some of the oil. However, a competing process would be the gradual thickening and hardening of the already thickened oil into a type of crust that would make further microbial degradation of the oil difficult. Therefore it is anticipated that wetland habitats significantly impacted by the oil would potentially experience long-term impairment, on the order of numerous months to years, potentially out as far as a decade.

Long-term and large volume oil releases could result in contamination of bottom sediments typically dredged by the Corps of Engineers in order to maintain Gulf navigation channels. Not only could this result in the need for additional dredged material "waste" disposal or containment sites, that material would not be available for use as a significant local source of material to rebuild degrading coastal marshes, intertidal areas, shorelines, and barrier islands. Additional subsea bed sediment "borrow sites" representing sources of suitable restoration material might be also become contaminated.

Federal, State, and local investments in Louisiana coastal restoration and protection have been significant for quite some time. However, post-Katrina expenditures have escalated and any negative impacts from the oil release to coastal restoration efforts could jeopardize the effectiveness of these expenditures.

EPA works with other federal agencies and the State of Louisiana in implementing the Coastal Planning, Protection, and Restoration Act (CWPPRA) projects and a number of these are at risk, including several EPA-lead projects in the eastern delta area of the Mississippi River. Depending on changing trajectories, many more could be impacted. EPA also provides a portion of the funding for the Barataria-Terrebonne National Estuary Program and the Gulf of Mexico Program, both of which are programs dedicated to restoring and protecting coastal resources at risk. EPA provides technical assistance to the Gulf Alliance of State Governors in their endeavors to protect Gulf resources. All of these efforts could be affected by the oil release, as could a myriad of other federal, state, local, private, corporate, and non-profit coastal protection and restoration programs and projects.

Mangroves

Petroleum and its by-products may injure and kill mangroves in a variety of ways. Crude oil coats roots, rhizomes, and pneumatophores and disrupts oxygen transport to underground roots (Baker, 1971). Oiling of mangroves following spills can lead to the death of those plants and ultimately unstable habitats and sediment erosion (NRC, 2003, Oil on the Sea III: Inputs, Fates, and Effects, National Research Council, 2003., (pg.146)). As with other intertidal communities, many of the invertebrates, fishes, and plants associated with the mangrove community are highly susceptible to petroleum products. Widespread destruction of organisms such a attached algae, oysters, tunicates, crabs, and gobies have been reported in the literature.

Shorelines

It is anticipated that the majority of the negative impacts of the oil as it approaches the shore and makes landfall will be the physical effects of the oil on the plants and animals that it comes into contact with. The degree of impact will be highly dependent upon the type of shoreline that is affected. Traditionally, sandy shore lines are relatively easy to clean, and the impacts from oil on the shore lines is usually not overly significant in a relative sense because the oil can be cleaned up in a reasonable timeframe once the source is stopped, and many of these types of shorelines are not as biologically active as areas such as marshes. Shore lines with coarser substrate such as gravel or cobble also are able to be cleaned to a large degree. However, impacts to coarse substrate shorelines would be more difficult to mitigate than for a fine sandy beach, simply due to the fact that the oil could penetrate further into a course substrate, and therefore cleanup efforts would have to be more extensive.

Chemical Impacts to the Environment

The oil in near-shore waters, as mentioned, is anticipated to be somewhat chemically weathered, with many of the lighter and more water soluble compounds mostly gone. However, some dissolving, further emulsifying or suspending of previously non-solubilized compounds due to surf zone activity may occur, and this could impact some of the very shallow water and intertidal organisms beyond what may be anticipated simply due to dissolved oil constituent toxicity. This may be especially true for the less mobile organisms such as crustaceans and mussels.

Biological Impacts

Oil spills may also cause shifts in population structure, species abundance and diversity, and distribution. Habitat loss and the loss of prey items also have the potential to affect fish and wildlife populations. Oil remains in the environment long after a spill event, especially in areas sheltered from weathering processes, such as the subsurface sediments under gravel shorelines, and in some soft substrates. Plant communities in coastal ecosystems have different susceptibilities to contamination. In temperate regions, salt marshes are most vulnerable. Many salt marsh plants are relatively short, measuring up to three feet in height. Because they are low, salt marsh plants can be completely covered by the oil after a spill causing dieback. This can influence the stability of the soil in wetland hammocks, causing erosion and loss of wetland habitat.

Coastal wetlands in Louisiana and Mississippi provide the critical breeding grounds and nurseries for 90% of marine species in the Gulf of Mexico.

The potential impacts may be greater given the particular season in which this spill is occurring. Many of the animals along the Gulf Coast, including fish and birds, are spawning and reproducing at this time. This brings fish and other aquatic animals into shallow water, increasing the potential risk to them. It also makes shoreline associated birds and other wildlife less likely to flee the oncoming oil, given their desire to maintain the reproductive seasonal territory many have just claimed.

The greatest negative impact to shoreline is anticipated to occur for marshes and mangrove shorelines. Mangrove roots are exposed to obtain oxygen, and when they are coated with oil the plants generally do not survive. It is not known how much of the shorelines of Louisiana, Mississippi, Alabama and the panhandle of Florida contain mangroves, but these are usually very productive and highly valued ecosystems. Grassy wetlands are also very sensitive to the impacts of oil, and much of the aforementioned shorelines, especially for Louisiana, Mississippi and Alabama, contain these types of habitats. As mentioned, much of the lighter and more water soluble fraction of the oil is anticipated to have been weathered from the land-falling crude, which should ameliorate the chemical toxicity hazards somewhat. However, the weathered crude is likely to coat whatever it touches.

It is likely that intertidal organisms would be the most adversely affected of the near shore aquatic organisms from the oil as it comes ashore. A non-direct effect of the oil on fish, shrimp, and similar animals may be from the effect on the marshes that they use as their rearing areas. Marshes are great nursery areas for larval and juvenile fish and other aquatic organisms, as they provide cover and food resources. If substantial areas of the coastal marshes are severely altered or impaired by the oil, this could have significant and long term effects on the populations of the fish, shrimp and related animals that use these areas.

Oil can be directly toxic to marine invertebrates or impact them through physical smothering, altering metabolic and feeding rates, and altering shell formation. These toxic effects can be both acute (lethal) and chronic (sub-lethal). Intertidal benthic (bottom dwelling) invertebrates may be especially vulnerable when oil becomes highly concentrated along the shoreline. Additionally, sediments can become reservoirs for the spilled petroleum. Some benthic invertebrates can survive exposure, but may accumulate high levels of contaminants in their bodies that can be passed on to predators. The coastal subtidal zone (underwater at all times) and intertidal zone (covered only during high tide) are inhabited by multiple small invertebrates. The fiddler crab, a species that inhabits the intertidal zone, is regarded as the "canary in a coal mine" for oil spills. This invertebrate is present in the estuarine habitats around the world and is therefore a universal indicator for the impact of oil spills on coastal ecosystems. As with other organisms, fiddler crabs exhibit dose response mortality due to oil toxicity. Thus the status of the fiddler crab population in an area after an oil spill is a sensitive marker for the severity of the spill.

Fisheries

Spills would indirectly affect commercial fisheries by degrading habitats critical for the survival of target species. These impacts would only be serious to commercial fisheries if they lead to significant declines in target populations of fish or invertebrates. This would likely require large areas of coastal habitat, including wetlands and seagrass beds, to be negatively impacted by a spill.

Oil spills reaching coastal and wetland areas could lead to the death of wetland vegetation, seagrass beds, and associated fauna. Saturation of sediments with oil and trapping of oil by vegetation could lead to chronic sources of pollution, resulting in long-term effects on important fishery resources. Mechanical destruction of wetland areas during cleanup could also result in long-term loss of nursery and foraging areas for some commercially important species of fish and invertebrates. On a large scale, this could result in significant impacts to fish or invertebrate populations. Areas where coastal wetlands front directly on the open Gulf are most vulnerable to oil spills.

Brown shrimp are now in the post-larval stage and are vulnerable to volatile aromatic hydrocarbons, which are soluble in water. If the oil finds its way onto the marsh edges and trainasses, shrimp mortalities will be high. Oysters are spawning now and the effects of being oiled could be disastrous. If exposed to oil, oysters will react by dedicating their energy resources to survival, rather than to reproduction. If they do succeed in reproducing but the cultch is oiled, the spat will not set and reproductive success could be jeopardized next year and possibly beyond. Oysters also filter large volumes of water increasing exposure to the oil. The oil could persist in the marsh and open water sediments and impact aquatic organisms for quite some time.

Marine Mammals

Among the most significant potential impacts from the spilled oil as it travels toward shore will continue to be the potential for oiling of marine mammals and seabirds as long as the oil is being released. The magnitude of the threat posed is unknown at this time, but it is anticipated that there may be significant impact simply due to the size of the slick.

An oil spill in coastal waters may affect the West Indian manatee. Because the distribution of this species is largely limited to coastal waters along the Florida peninsula, with some individuals venturing into coastal waters of the Florida Panhandle and occasionally the central and western Gulf, the West Indian manatee would be most vulnerable to a spill occurring in or reaching the preferred river system and canals where it congregates.

Marine and Coastal Birds

Sensitive coastal areas of Louisiana, Mississippi, Alabama and Florida are all vulnerable to the expanding oil release, which is occurring at the height of the nesting season for many marsh and wading birds. In addition, it is grim news for the migratory birds that rely on healthy coastal upland and wetland habitats to rest and refuel after their long spring flights over the Gulf of Mexico. (See http://www.audubon.org/news/pressroom/gos/birdprofiles.html). These coastal areas are home of the two largest flyways for migratory waterfowl and songbirds which depend upon the ecosystem services of these coastal wetlands as they travel seasonally between North and South America. There are four groups of birds that inhabit the Gulf of Mexico region for at least some portion of their life cycle. These groups include: seabirds, shorebirds, wetland birds, and waterfowl.

The National Audubon Society has identified some of the birds most vulnerable along the Louisiana coast (See also Appendix C). A number of species are prompting special concern, including the brown pelican — just removed from the endangered species list, and beach-nesting terns and gulls (Caspian tern, royal tern, sandwich tern, least tern, laughing gull, black skimmer) and shorebirds (American oystercatcher, Wilson's plover, snowy plover). The coastal reddish egret, large wading birds (roseate spoonbill, ibises, herons, egrets), and marsh birds (mottled duck, clapper rail, black rail, seaside sparrow, marsh-dwelling songbirds) are all threatened as well. Ocean-dwelling birds, like the magnificent frigatebird, could be affected if they come in contact with the oil.

Many of these birds nest and roost on barrier islands and beaches. They are at risk if oil comes ashore or affects their food sources. Some species have begun nesting or building pair bonds in preparation for nesting. Many currently exhibit low reproductive rates and a disruption to their breeding cycle this year could have serious effects on the population for years to come. They feed on fish and other estuarine organisms, such as small invertebrates or oysters. Because they roost and nest directly on the sand and plunge-dive into the water to catch fish, they are extremely vulnerable both to oil on the surface of the water and oil washing ashore. Birds may become fouled with oil by diving through oil slicks to capture prey, or by wading and walking through contaminated areas, then preening feathers and ingesting the oil.

Brown pelicans can be differentially impacted because they show fidelity to their rookery and may be less inclined to move away from oil. Oil pollution that does not cause immediate death can potentially impair long-term survival and reproduction.

The seasonal migration of birds moving from South America back north will likely mean an increase in the number and variety of birds that may come into contact with the oil, compared to other times of the year. The impact on the migratory birds as well as the spawning/reproducing animals will be determined by how long it takes the oil to reach the main shoreline areas, although the trajectories already show the oil reaching a few of the smaller but ecologically important barrier islands. Nonetheless, it is anticipated that the timing of the oil landfall may make a difference in the numbers and types of organisms that may be adversely affected. A large incident could overwhelm efforts to rescue birds resulting in large-scale mortality.

It is anticipated that a significant impact will be on birds. This spill is occurring at the height of the nesting season for many marsh and wading birds. Birds may be adversely affected through direct contact with the spilled oil (including ingestion of tar balls mistaken for food), by the fouling of their habitats and contamination of their food by the oil, and as a result of oil-spill response activities. Exposure of eggs, young, and adult birds to oil may result in a variety of lethal and sublethal effects. Fouling of habitats can reduce habitat quality, while contamination of foods may lead to a variety of lethal and sublethal toxic and physiological effects. Finally, oil-spill response activities may disturb birds in the affected habitat as well as nearby habitats that are unaffected by an oil spill.

Adult and young birds may come in direct contact with oil on the water's surface or on oiled beaches, mudflats, and other shoreline features. Oil may also be physically transferred by nesting adults to eggs or young. Direct contact with oil by young and adult birds may result in the fouling or matting of feathers, which would impact flight and/or diving capabilities, affecting such activities as foraging and fleeing predators. Birds that have been fouled by oil also experience a loss in the insulating properties of their feathers, making them susceptible to hypothermia during cold weather periods. Oil making contact with skin, eyes, or other sensitive tissues may result in an irritation or inflammation of skin or sensitive tissues (Fry and Lowenstine, 1985), while oiled eggs would incur reduced gas exchange.

Birds may ingest oil incidentally while foraging and while preening oiled feathers. Ingested oil may depress egg laying activity or may result in the death or deformities of young (Fry et al., 1985; Leighton, 1990). Direct effects of oil contact may be amplified under conditions of environmental stress such as migration movements and molting. Indirect effects of oil contact include toxic effects from the consumption of contaminated food or starvation from the reduction of food resources (Lee and Socci, 1989). The latter effects may hinder the recovery of impacted bird populations after a spill (Hartung, 1995; Piatt and Anderson, 1996; Piatt and Ford, 1996).

Threatened or Endangered Species

Sea turtles are about to nest on beaches which could become oiled. The West Indian manatee (Trichechus manatus) inhabits only coastal marine, brackish, and freshwater areas (see previous Marine Mammals section). Several species of endangered or threatened coastal species of birds populate the northern Gulf of Mexico during at least part of the year. In gulf waters, habitats include offshore areas, coastal beaches, and contiguous wetlands (MMS, 2002a).

All sea turtle life stages, as well as nest sites and eggs could be vulnerable to an oil spill. Nests may be exposed by oil washing ashore and soaking through overlying soils onto buried eggs, while hatchlings may be exposed as they emerge through the overlying oiled sands or as they make their way over oiled sands to the surf. Hatchlings, juveniles, and adults may be exposed while swimming through oil on the water surface, through inhalation of petroleum vapors, and through ingestion of contaminated foods and floating tar. Nesting adults (females) may also be exposed while coming ashore on oiled beaches. In addition to direct adverse effects from such exposures, adults and juveniles may also be indirectly affected if the spill reduces the quality or quantity of foraging or nesting habitats. Impacts to nesting habitats could result in population level effects.

Sea turtle nest sites and emerging hatchlings may be exposed to and subsequently affected by oil spills that wash up on nesting beaches and contaminate active nests. Oil may interfere with gas exchange within an oiled nest, may alter hydric conditions of the sand so that it is too wet or too dry for optimal nesting, or may alter nest temperatures by changing the color or thermal conductivity of the overlying sand (NOAA, 2003). Adult females may refuse to use oiled beaches (NOAA, 2003).

Eggs exposed to freshly oiled sands may incur a significant decrease in survival to hatching and an increase in developmental abnormalities in hatchlings (Fritts and McGehee, 1982). In contrast, eggs exposed to weathered oil did not produce measurable impacts on hatchling survival or development, suggesting that impacts to nest sites would be greatest if the oil spill occurred during the nesting season. Because most sea turtles nest above the high-tide line, and oil washing ashore would be deposited at and just above the high-tide line, oiling of actual nests is unlikely except possibly in the event of exceptionally high tides or storms. Hatchlings may become oiled while traveling from the nest to water, and a heavy oil layer or tar deposits on the beach may prevent the hatchlings from reaching water. Oiled hatchlings may have difficulty crawling and swimming, increasing the potential for predation.

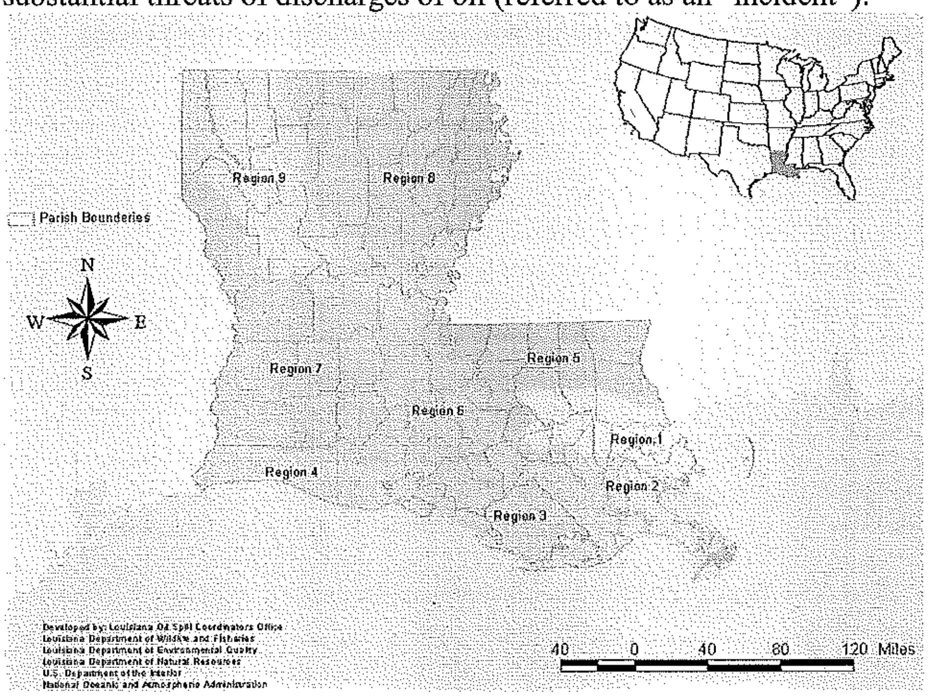
Hydrocarbons from spilled oil can affect adult sturgeon by direct contact with gills or via direct ingestion. Toxic fractions of PAH's in spilled oil can cause death or illness in adult fishes, but exposure to these fractions must be continuous. Adult and juvenile fishes would likely avoid a large oil spill; however, the demersal (on the bottom) eggs and riverborne larvae of Gulf Sturgeon would be unable to avoid spilled oil. Eggs and larvae of fishes would die or become deformed if exposed to certain toxic fractions of spilled oil (Longwell, 1977; Carls and Rice, 1990; Collier et al., 1996; Kingsford, 1996). The Gulf sturgeon deposits demersal eggs (which hatch in about 1 week) in freshwater reaches of the major rivers from eastern Louisiana to Florida, usually in deep areas or holes with current flow. Floating oil is not likely to penetrate to the middle reaches of most rivers where eggs are deposited because it would float on the freshwater outflow and never reach or settle directly on demersal eggs (Sulak and Clugston, 1998; Fox et al., 2000).

Appendix A

The Louisiana Regional Restoration Planning Program
Final Regional Restoration Plan
Region 2
January 2007
Louisiana Department of Environmental Quality
Louisiana Department of Natural Resources
Louisiana Department of Wildlife and Fisheries
Louisiana Oil Spill Coordinator's Office, Office of the Governor
National Oceanic and Atmospheric Administration
U.S. Department of the Interior

Selected Excerpts from the Introduction:

Federal and Louisiana natural resource trustees have developed a statewide Louisiana Regional Restoration Planning Program to assist the natural resource trustees in carrying out their Natural Resource Damage Assessment (NRDA) responsibilities for discharges or substantial threats of discharges of oil (referred to as an "incident").



Region 2 encompasses the Breton Sound and Barataria hydrologic basins and the lower Mississippi River basin, delta plain, and modern Balize (Birdfoot) delta. Bordered to the north by the headwaters of Bayou Lafourche and the Mississippi River, Region 2 extends south to the Caminada-Moreau Headland, Plaquemines barrier system, and Birdfoot delta, and from Bayou Lafourche along its western border to the Mississippi River and Mississippi River Gulf Outlet along its eastern border. The following parishes are located either partly or completely within Region 2: Ascension, Assumption, Jefferson, Lafourche, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, and St. John the Baptist.

*Selected Excerpt from Chapter 2, **Affected Environment and Resources: Biological Resources:***

As Figure 2, *Region 2 Boundary, Parishes, and Associated Habitat Types,* illustrates, Region 2 habitats are dominated by coastal herbaceous wetlands (*i.e.*, fresh, intermediate, brackish, and salt marsh) and open waters in the seaward areas, while forested wetlands with some agricultural cropland/grassland and upland vegetated habitat occur in the interior portions of the Region. The following habitat types are present in Region 2 (detailed descriptions of each are provided in the Louisiana Regional Restoration Planning Program FPEIS [NOAA *et al.* 2007]):

- Marsh (Salt, Brackish/Intermediate, Flotant, and Fresh);
- Wetland Forest (Evergreen, Deciduous, and Mixed);
- Wetland Scrub/Shrub (Evergreen, Deciduous, and Mixed);
- Agriculture-Cropland-Grassland;
- Wetland Barren;
- Open Water;
- Marine/Estuarine Shore;
- Freshwater Shore;
- Marine/Estuarine and Freshwater Benthic (Soft-Sedimentary);
- Marine/Estuarine Encrusting Community (Natural/Artificial Substrates);
- Living Reefs;
- Marine/Estuarine Submerged Aquatic Vegetation (SAV);
- Mangrove Swamp;
- Batture;
- Upland Forest; and
- Upland Scrub/Shrub (Evergreen, Deciduous, and Mixed).

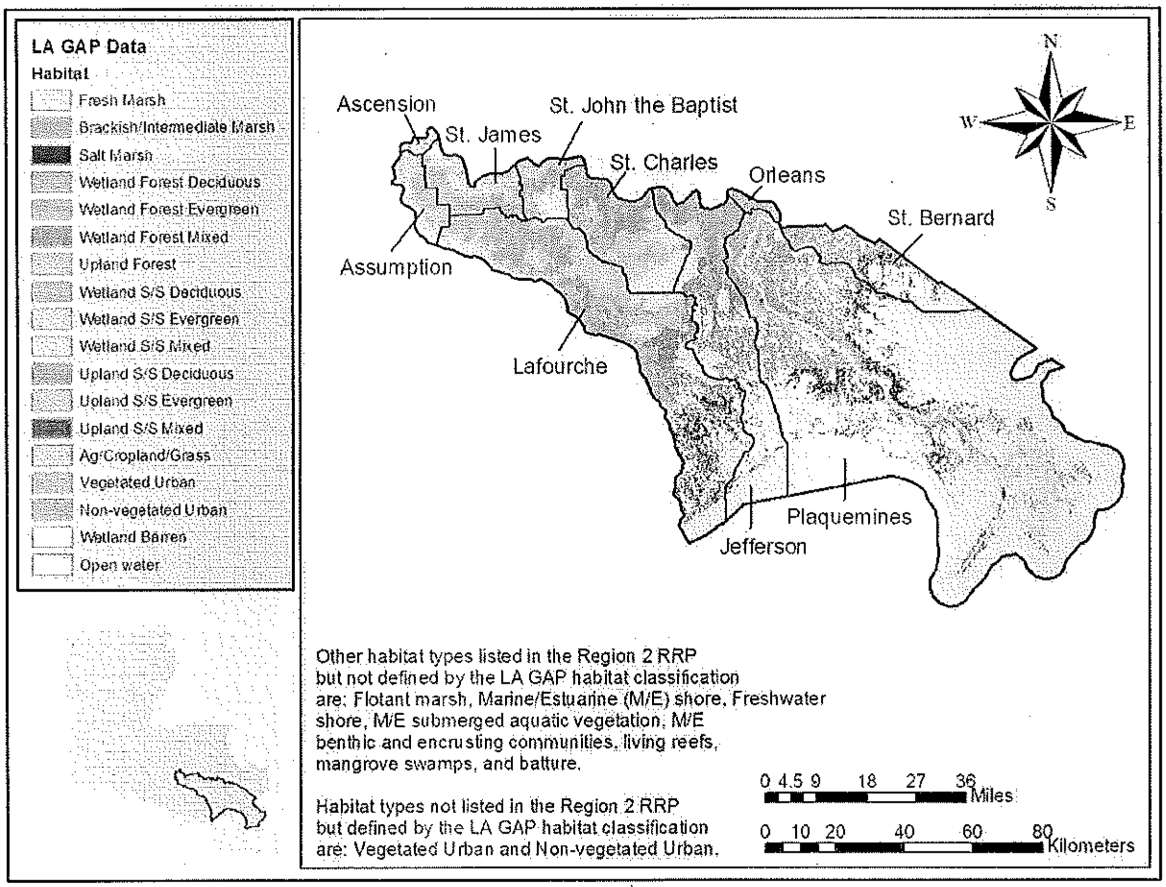


Figure 2: Region 2 Boundary, Parishes, and Associated Habitat Types (adapted from Hartley et al. 2000)

Common biota associated with these habitat types are summarized in Appendix A, *Common Biota and Associated Habitat Types in Region 2* (Vegetation, Table A-1; Mammals, Table A-2; Reptiles and Amphibians, Table A-3; Birds, Table A-4 through Table A-9; Fish and Shellfish, Table A-10). Detailed descriptions of wildlife species associated with these habitat types are also described in the Louisiana Regional Restoration Planning Program FPEIS (NOAA *et al.* 2007).

The Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority (1998), as part of their Coast 2050 plan, identified 21 wildlife species and species groups that rely on the habitats in Region 2 for all or part of the year. These include wading birds, seabirds and shorebirds, raptors, woodland residents including various birds and mammals, and the American alligator.
As of March 2004, the published list of threatened and endangered species for the State of Louisiana includes 32 animal and three plant species (U.S. Department of the Interior, [USDOI] 2004). The following 12 threatened and endangered animal species are found in Region 2 (see Table A-11, *Threatened and Endangered Species in Region 2 and their Associated Habitats*):

inflated heelsplitter (*Potamilus inflatus*); bald eagle (*Haliaeetus leucocephalus*); brown pelican (*Pelecanus occidentalis*); piping plover (*Charadrius melodus*); green sea turtle (*Chelonia mydas*); hawksbill sea turtle (*Eretmochelys imbricata*); Kemp's (Atlantic) ridley sea turtle (*Lepidochelys kempii*); leatherback sea turtle (*Dermochelys coriacea*); loggerhead sea turtle (*Caretta caretta*); Gulf sturgeon (*Acipenser oxyrinchus desotoi*); pallid sturgeon (*Scaphirhynchus albus*); and West Indian manatee (*Trichechus manatus*). Critical habitat has been designated for the piping plover and Gulf sturgeon. There are no endangered plants identified in Region 2.

*Selected Excerpt from Chapter 2, **Affected Environment and Resources**:* Socioeconomic Resources

Infrastructure within Region 2 includes 13 highways (that pass through or border the region), 77 miles of primary roads, 322 miles of secondary roads, 2,631 miles of tertiary roads, and approximately 218 miles of railroads (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). Major bridges within or adjacent to Region 2 include the Sunshine Bridge, the bridge at I-310, the Huey P. Long Bridge, and the Crescent City Connection. In addition, smaller crossings over Bayou Lafourche include, but are not limited to, bridges at Rita, Raceland, Thibodaux, Freetown, and Plattenville. There are numerous private helipads in Region 2, and the nearest public heliport is located just north of Region 2 at the Louis Armstrong New Orleans International Airport. In addition, there are numerous sea planes available in the Region to rent from private companies. Commercial and recreational ports located either within or adjacent (when noted) to Region 2 include:

- Port Fourchon;
- New Orleans (adjacent);
- Braithwaite;
- LaPlace (adjacent);
- Grand Isle;
- Metairie (adjacent);
- Empire-Venice port;
- Delacroix port;
- Grand Isle port; and
- Lafitte port.

The Gulf Intracoastal Waterway, a critical shallow-draft transportation link, traverses Region 2. In addition, the Bayou Segnette Waterway, South Pass Channel, U.S. Army Corps of Engineers (USACE) maintained Barataria Bay Waterway, and the waterway from Empire to the Gulf of Mexico traverse Region 2. The Mississippi River main stem levee system, comprised of levees, floodwalls, and various control structures, traverses Region 2.

The inland waters, coastal marshes, and offshore waters of Region 2 support commercial fishing and aquaculture industries. There is little forest industry in Region 2. Sugarcane, citrus, and commercial fruits and vegetables are important agricultural products. Animal furs and alligator skins are also important commodities in Region 2.

Oil and gas production is important in the region. There are more than 1,500 miles of oil and gas pipelines and more than 15,000 oil and gas wells located within Region 2 (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). The Louisiana Offshore Oil Port (LOOP), which provides deepwater tanker offloading and temporary storage of crude oil, has a pipeline that delivers product onshore through Barataria Bay to Clovelly Farms. The LOOP receives approximately 13% of the United States' imported crude oil. Onshore salt domes located near Galliano have a 40 million barrel capacity to receive oil from the LOOP terminal (LA 1 Coalition 2003).

Region 2 has both State and National Parks that provide for the recreational use and/or preservation of natural and cultural resources. Bayou Segnette and Grand Isle State Parks are both located in Jefferson Parish. Jean Lafitte National Historic Park and Preserve, operated by the National Park Service, is located in Orleans Parish. In addition, residents of, and visitors to, Region 2 take advantage of the numerous habitat types and wildlife and fisheries resources, which provide opportunities for wildlife viewing, hunting, fishing, boating, swimming, hiking, biking, camping, and picnicking. Tourism in Region 2 is a multibillion dollar industry (Louisiana Department of Culture, Recreation, and Tourism 2005). Within Region 2, the Louisiana Department of Wildlife and Fisheries (LDWF) manages the four Wildlife Management Areas (WMAs) of Salvador/Timken, Wisner, Maurepas, and Pass-a-Loutre. The U.S. Fish and Wildlife Service (USFWS) manages the Delta and Breton National Wildlife Refuges. Bayou Des Allemands borders Lafourche and St. Charles Parishes and is a state-designated scenic river.

Appendix B

Natural/Physical Protection Environmental Sensitivity Maps In accordance with USCG Sector New Orleans Area Contingency Plan

The majority of Louisiana and Mississippi is considered to be environmentally sensitive. The below listed references should be used during incidents to determine the location of shoreline types, habitat types, biological resources, National and State wildlife refuges, and parks. For more detailed environmental sensitivity maps of Louisiana go to the following link: NOS Data Explorer This reference also provides Environmental Sensitivity Indexes (ESI) for shoreline types. Or refer to the environmental sensitivity charts in the Region VI toolkit. Sensitivity Maps http://wwwdb.glo.state.tx.us/oilspill/Atlas/atlas/acp/neworleans/esi_datala/index.PDF

Coastal Geography

The following figures and lists depict the general make-up of the Louisiana Coast. These figures show features in USCG Sector New Orleans Area Contingency Plan.
http://wwwdb.glo.state.tx.us/oilspill/Atlas/atlas/acp/neworleans/msoneworleansgrp.pdf

Coastal Structures
The coastal structure classification describes the variety of man-made hard structures that can be found on the shoreline. This classification includes seawalls, jetties, breakwaters, groins, piers, port facilities, pipelines, and oil and gas facilities. The typical construction material and texture include rock, steel, wood, and concrete.

- **Seawalls:** Seawalls are coastal protection structures built parallel to shore and constructed of rock or concrete rip rap, concrete textiles, wood or concrete wall, or just debris and junk such as old cars.
- **Jetties:** Jetties are shore-normal navigation structures typically built of rock riprap.
- **Breakwaters:** Breakwaters are shore-parallel, segmented seawalls that are placed in the surf zone to retard coastal erosion. Breakwaters are built of rock riprap and wood.
- **Groins:** Groins are short, shore-normal coastal structures that extend from the shoreline into the surf zone in order to trap sediment and slow coastal erosion. The typical construction material is wood.
- **Piers:** Piers describe shore-normal and shore-parallel structures that provide working platforms extending from the shore. The typical construction technique is wood or concrete pilings supporting a deck.
- **Port Facility:** Port facility is used to describe major developed waterfronts built of seawalls, piers, and other coastal structure types. The primary construction materials include steel, rock, wood, and concrete.
- **Pipelines:** Numerous pipelines make landfall and associated with them are typically a small timber or rock seawall protecting the dredging access area.

- **Oil and Gas Facilities:** Oil and gas facilities occur throughout the area and consist of platforms, tank farms, production plants and more. Primary construction materials are steel, concrete wood, and rock.

Coastal Structure Environmental Concerns

- **Sensitivity:** The environmental sensitivity of coastal structures is low because of the limited habitat these features create and the amount of animal and plant colonization they attract.
- **Oil Behavior:** Oil typically coats these structures with little penetration and mineral impact on the sparse plant and animal life associated.
- **Cleanup:** Oil penetration is limited to surface roughness features and cracks. Some of the major cleanup concerns are logistics and the recovery of treated oil. This environment typically can handle the use of intrusive cleanup techniques such as low and high-pressure wash.

Bluffs

The bluff classification is used to describe a shoreline backed by an eroding bluff and fronted by a narrow sand beach. The bluff erodes by slope failure and wave undercutting. Narrow beaches are a mixture of fine and coarse sand as well as organic debris. In many cases, the slope failure process deposits trees, shrubs, scrubs, and man-made features such as roads and homes onto the shoreline. The fringing beaches tend to be moderately sloping with a distinct storm berm and multiple near-shore bars on a shallow platform.

Bluff Environmental Concerns

- **Sensitivity:** The environmental sensitivity of this shoreline type is low due to limited plant and animal colonization.
- **Oil Behavior:** Oil typically stains the sediments and the near-shore debris with low permeability.
- **Cleanup:** The sediment penetration potential is low due to a high water table. Some of the cleanup concerns center on poor access and transitability.

Fine Sand Beaches

The fine sand beach classification describes beaches with low slopes and a grain size of 0.0625 to 0.200 mm. These beaches can be natural or man-made. Generally, there is always a low percentage of shells and shell hash. Typical beach widths are 20 - 100 m.

Fine Sand Beach Environmental Concerns

- **Sensitivity:** Fine sand beaches have a low sensitivity to oil spill impacts and cleanup methods.
- **Oil Behavior:** Oil typically stains and covers the beach sands with low permeability.
- **Cleanup:** The penetration is low to moderate depending on the water table and the position of the oiling on the shoreline. A major environmental concern during beach

cleanup is the protection of the dune habitat from the cleanup operations. Fine sand beaches typically have poor access, but good transitability. Fine sand beaches are relatively easier to clean in contrast to marshes. Large volumes of stained sand and debris can be generated by beach cleanup.

Coarse Sand Beaches

The coarse sand beach classification describes beaches with moderate slopes and grain of 0.2 - 0.4 mm. These beaches can be natural or man-made. Generally, there is a low percentage of shells and shell hash. Typical beach widths are 10-50 m. There are no true coarse sand beaches in Louisiana due to the character of the sediment load in the Mississippi River. The coarse sand shoreline type is included here, for completeness because the 12-shoreline types apply to the northern Gulf of Mexico coast.

Coarse Sand Beach Environmental Concerns

- **Sensitivity:** The environmental sensitivity of coarse sand beaches is low due to the limited animal and vegetation population.
- **Oil Behavior:** Spilled oil typically stains and coats coarse grain beach sands with moderate to high permeability.
- **Cleanup:** Sediment penetration on coarse grain beaches is moderate/high depending on the water table and the location of oil deposition. A major environmental concern is the protection of the dune habitat from cleanup operations. The transitability of this shoreline type is less than fine sand beaches because the bearing strength is lower and this type of sand builds steep beach faces. Access is typically poor.

Shell Beaches

The shell beach classification is used to describe shoreline types comprised almost entirely of shell. The shell material may be in the form of shell hash or whole shells. The sources for the shells include the near-shore zone or back barrier areas. The major shell shorelines are found on the Mississippi River Chenier and delta plains. Typically in Louisiana, shell beaches form where coastal erosion is reworking former back barrier environments containing rangia and oyster reefs. Shell beaches form extremely steep beach faces because of the coarse shell fragments and whole shells making up the shoreline.

Shell Beach Environmental Concerns

- **Sensitivity:** The environmental sensitivity of shell beaches is moderate due to the use of this shoreline by estuarine organisms and extensive wash over terrace development.
- **Oil Behavior:** Oil typically stains and coats the shell hash and whole shells comprising the beach with high sediment penetration.
- **Cleanup:** The oil penetration is high due to the porous beach character created by the shell material. This beach type quickly turns into an asphalt pavement under heavy oiling conditions. Shell beaches have poor transitability due to the low bearing strength and steep beach face. Shell beaches usually have poor access in Louisiana.

Perched Sand Beaches

The perched sand beach classification is used to describe a shoreline type where a thin sand beach (fine or coarse) overlies a fresh marsh or salt marsh with an eroded marsh platform outcropping in the surf zone. This shoreline type is common in the Mississippi River Chenier and delta plains. Perched sand beaches can occur as a continuous straight shoreline or as a series of contiguous pocket beaches. Organic and shell debris is common to this shoreline type. Where the marsh platform outcrops on the shoreline, it can become re-vegetated by marsh grass. Perched sand beaches are erosional. It is the erosion of a marsh shoreline that produces a thin low prism of sand that overlies the eroded marsh outcrop.

Perched Sand Beach Environmental Concerns

- **Sensitivity:** The environmental sensitivity of perched sand beaches is moderate due to the presence of wetland habitat.
- **Oil Behavior:** Oil typically coats and covers sediment and vegetation with low to moderate sediment penetration.
- **Cleanup:** The sediment penetration potential is low/moderate depending on the water table level and sediment thickness. A major environmental concern is the cleanup of wetland habitat associated with perched sand beaches. This shoreline type ischaracterized by poor transitability and access.

Perched Shell Beaches

The perched shell beach classification as used to describe a shoreline type where a thin shell beach overlies a fresh or salt marsh with an eroded marsh platform outcropping in the surf zone. This shoreline type is common in the Mississippi River chenier and delta plains. Perched shell beaches can occur as a continuous straight shoreline or as a series of contiguous pocket beaches. Organic debris is common to this shoreline type. Where the marsh platform outcrops on the shoreline, it can become re-vegetated by marsh grass. Shell beaches are erosional. It is the erosion of a marsh shoreline that produces a thin prism of shell material that overlies the eroded marsh outcrop.

Perched Shell Beach Environmental Concerns

- **Sensitivity:** The environmental sensitivity of perched shell beaches is moderate due to the presence of wetland habitat
- **Oil Behavior:** Oil typically coats and covers sediment and vegetation with high sediment penetration.
- **Cleanup:** The sediment penetration potential is moderate/high depending on the water table level and sediment thickness. A major environmental concern is the cleanup of wetland habitat associated with perched shell beaches. This shoreline type is characterized by poor transitability and access.

Sandy Tidal Flats

The sandy tidal flat classification is used to describe shoreline types comprised of broad intertidal areas consisting of fine and coarse grain sand and minor amounts of shell hash. The mean grainsize ranges between 0.0625 mm and 0.4 mm. Sandy tidal flats are typically found in association with barrier island and tidal inlet systems. Sandy tidal flats are submerged during each tidal cycle. At low tide, a typical sandy tidal flat may be 100-200 m wide. The most common sandy tidal flat occurrences are associated with flood-tidal deltas, recurved spits, and back barrier areas. Salt marsh vegetation often develops along the upper intertidal areas of sand flats. Due to the low tidal flat gradient, slight changes in water levels can produce significant shoreline changes. Low water levels can expose extensive tidal flat areas to oiling.

Sandy Tidal Flats Environmental Concerns

- **Sensitivity:** The environmental sensitivity of sandy tidal flats is moderate due to the presence of wetland habitat.
- **Oil Behavior:** Oil typically stains and covers sediment and vegetation with low to moderate sediment penetration.
- **Cleanup:** The oil penetration potential is low/moderate depending on the water level and the location of oil deposition. The transitability of sandy tidal flats is moderate/good depending on substrate character. Major environmental concerns related to cleanup include the protection and cleanup of wetland habitat and further subsurface contamination due to trampling and equipment movement. Tidal flat access in Louisiana is typically poor.

Muddy Tidal Flats

The muddy tidal flat classification is used to describe shoreline types comprised of broad intertidal areas consisting of mud and minor amounts of shell hash. The grain size is finer than 0.0625 mm. Muddy tidal flats are typically found in association with prograding river mouths. Muddy tidal flats are soft, dynamic shorelines rich in newly developing habitat. Mudflats located at prograding river mouths are vegetated by willow tree and sugar cane swamps. Prograding mudflats on the coast are vegetated by lush growths of salt marsh.

Muddy Tidal Flats

- **Sensitivity:** The environmental sensitivity of muddy tidal flats is high due to presence of developing wetland habitat. Oil usually coats and covers sediment and vegetation.
- **Oil Behavior:** Oil typically stains and covers sediment and vegetation.
- **Cleanup:** The sediment penetration potential is low due to the high water table and water content in the sediment. The major environmental concern associated with muddy tidal flats is the damage done by the cleanup of wetland habitats as well as their protection from cleanup operations. Both access and transitability of muddy tidal flats is poor. The

potential exists for further contamination of subsurface sediments due to trampling and equipment movement.

Swamps

The swamp classification describes shoreline types that are comprised of scrubs, shrubs, evergreen trees, and hardwood forested wetlands. This shoreline type is essentially a flooded forest. This shoreline type is common in the river valleys of the chenier plain, and the interior areas of the delta plain. The sediments within the interior swamps tend to be silty clay and contain a large amount of organic debris.

Swamps Environmental Concerns

- **Sensitivity:** The environmental sensitivity is high for swamps because of the presence of wetland habitat.
- **Oil Behavior:** Oil usually coats and covers the sediment and vegetation with low sediment penetration.
- **Cleanup:** The sediment penetration potential is low due to the high water table and the water content of the sediments. A major environmental concern is that the cleanup may be more damaging than the oil itself. The access and trafficability of swamps are poor due to the soft sediment and the presence of dense tree growth.

Fresh Marshes

The fresh marsh classification is used to describe shoreline types found in the coastal interior. Freshwater marshes include floating aquatic mats, vascular submerged vegetation, needle and broad-leaved deciduous scrubs and shrubs, and broad-leaved evergreen scrubs and shrubs. The sediments are highly organic and muddy. Fresh marshes are characterized by high biodiversity and rich wetland habitat. This shoreline type is found within the river valleys that dissect the chenier plain as well as between the individual ridges. On the delta plain, freshwater marshes occur in the upper reaches of individual delta complexes as well as along distributary courses.

Fresh Marsh Environmental Concerns

- **Sensitivity**: The environmental sensitivity of fresh marshes is high because of the presence of wetland habitat.
- **Oil Behavior:** Oil usually coats and covers the sediment and vegetation with low sediment penetration.
- **Cleanup:** The sediment penetration potential is low due to the high water table and water content of the sediments. A major environmental concern about fresh marsh is that the cleanup can be more damaging than the oil itself, left alone. Transitability of fresh marsh is poor due to the soft sediment. Access is typically poor in Louisiana.

Salt Marshes

The saltwater marsh classification describes shoreline types that are wet grasslands vegetated by salt-tolerant species. This shoreline type includes saline, brackish, and intermediate marsh types. Saltwater marshes are extensive throughout the outer fringe of the Chenier and delta plains.

Salt Marsh Environmental Concerns

- **Sensitivity:** The environmental sensitivity is high for salt marsh because of the presence of wetland habitat.
- **Oil Behavior:** Oil usually coats and covers the sediment and vegetation with low sediment penetration.
- **Cleanup:** The sediment penetration potential is low/moderate due to the high water table and water content of the sediment. A major environmental concern is that the cleanup may be more damaging than the oil itself. The transitability of salt marsh is poor. Access is typically poor in Louisiana.

Wildlife and Fisheries Area

Louisiana are characterized by many wildlife and fisheries areas. Below are some of the major wildlife and fisheries areas in the COTP New Orleans zone.

Louisiana

Lake Pontchartrain

- Manchac Wildlife Management Area - Pass Manchac.
- Fontainebleau State Park and State Game Preserve- Lake Pontchartrain at Mandeville.
- Bayou Savage Management Area.

Lake Salvador.

- Jean Lafitte National Historic Park and Reserve.
- Salvador Wildlife Management Area- Lake Salvador.

Barataria Bay.

- Grand Isle State Park - Barataria Bay.

Lake Borgne

- Fort Pike State Commemorative Area - Lake Borgne.

Breton Sound

- Biloxi Wildlife Management Area.
- Breton National Wildlife Refuge - Chandeleur Islands and Breton Island.

Atchafalaya River and Atchafalaya Basin

- Atchafalaya National Wildlife Refuge - primarily freshwater marsh.

Lower Mississippi River (LMR) Mile 0 to mile 504.

The shoreline of the Mississippi River consists primarily of urban waterfront structures (low sensitivity), freshwater marshes (high sensitivity), and some saltwater marsh areas in the lower delta.

Socio/Economic Sensitive Area Mile 80 to mile 234.
These miles constitute the industrial corridor. Incidents affect numerous Mississippi River industries, including commercial vessel traffic, barge fleet operations, oil and HAZMAT transfer operations, and towing industry traffic and operations. Additionally, casino boats operate on the Mississippi River in Baton Rouge.

Lake Pontchartrain

Recreational boats, the casino industry, the towing industry, and oil and HAZMAT production companies vastly use Lake Pontchartrain. Numerous marinas exist on both the North and South shores of the lake. Two casino boats are located on the south shore.

Industrial Canals.
- Harvey Canal.
- Algiers Canal.
- Inner Harbor Navigation Canal.

Locks
- Harvey Canal.
- Algiers Canal.
- Inner Harbor Navigation Canal.
- Bayou Sorrel.
- Port Allen.
- Red River.

Intracoastal Waterway (ICW).

The ICW runs the width of the COTP New Orleans zone, and is heavily used by towing industry and commercial fishermen.

Mississippi River Gulf Outlet (MRGO)

Container vessels traverse the MRGO to offload product at the Inner Harbor Navigation Canal area.

Commercial Fishing Routes.
- Baptiste Collette.
- South Pass.
- Tiger Pass.
- Empire Canal.

- Barataria Waterway.

Archeological/Historical Sensitive Areas

Due to numerous archeological sites along coastal Louisiana, the Louisiana Division of Archeology and the Mississippi Department of Historical Preservation need to be informed of oil spills that may affect their natural coastline. Specifically, they need to be notified if the spill response operations will require disturbing the terrain through digging or transplanting. This does not include normal operations that just require access to the land.

Appendix C

Impacts to Birds

(from http://www.audubon.org/news/pressroom/gos/birdprofiles.html)

Brown Pelicans

The brown pelican was only recently removed from the endangered species list and just began breeding in the area. They nest colonially on barrier islands and feed on fish in nearshore waters. They have just begun their breeding season, and many pairs are already incubating eggs. Brown Pelicans were removed from the U.S. endangered species list only late last year, but they remain vulnerable to storms, habitat loss and other pressures. Their reproductive rate is relatively low, and a disruption to their breeding cycle this year could have serious effects on the population.

Beach-nesting terns and gulls

These birds nest and roost in groups on barrier islands and beaches. Some species have begun nesting or building pair bonds in preparation for nesting. They feed on fish and other marine life. Because they roost and nest directly on the sand and plunge-dive into the water to catch fish, they are extremely vulnerable both to oil on the surface of the water and oil washing ashore.

Beach-nesting shorebirds

These birds nest on the ground on barrier islands and beaches. They feed on small invertebrates along the beach or – in the case of oystercatchers – on oysters. They are at risk if oil comes ashore or affects their food sources. Reddish Egrets are large, strictly coastal egrets known for wild dance-like behavior as they hunt for prey in the surf. Their numbers have dwindled due to habitat loss and disturbance, and because they are specialized residents of coastal environments, they have nowhere else to go if their feeding and nesting grounds are fouled by oil.

Large wading birds

Many herons, egrets and other species feed in marshes and along the coast and they nest in large colonies called rookeries. They are vulnerable if oil comes ashore in areas where they nest and feed. The central Gulf Coast region hosts continentally significant populations of many of these birds. Examples include roseate spoonbills, white ibises, great blue herons, and great egrets.

Marsh birds

Secretive marsh-dwelling birds are at risk if significant amounts of oil wash into coastal salt marshes. Because many of these birds are so secretive, their population dynamics are already poorly understood, and recovery efforts would be difficult or impossible if oil accumulates in the marshes where they live.

Ocean-dwelling birds

Birds that spend a significant portion of their lives at sea (including Magnificent Frigatebird, Fregata magnificens) may be affected by oiled seas. If they make contact with the oiled water, they could ingest oil or get it on their feathers, and the presence of the oil could also affect their food supplies. These birds are difficult to monitor, and potential impacts of the spill on their populations is not fully understood.

Migratory shorebirds (plovers, sandpipers and relatives)
These birds' lives span the entire western hemisphere. Many species are currently en route from wintering grounds in South America to breeding grounds in boreal forests and arctic tundra. They congregate in great numbers on beaches and barrier islands to rest and refuel during their long journeys.

Migratory songbirds (warblers, orioles, buntings, flycatchers, swallows, and others)
Many of our most colorful and familiar summer songbirds fly nonstop across the Gulf of Mexico twice each year as they migrate between their breeding grounds and wintering grounds. The biggest push of spring migrants moves across the gulf during a two-week period from late April to early May. The journey across 500 miles of open water strains their endurance to its limits. They depend on clear skies and healthy habitats on both sides of the gulf in order to survive the journey.

Q's and A's for Ecological Impacts
(5/11/2010 Eco Impacts Team)

Outline

- General Questions
- Biological Impacts
- Threatened and Endangered Species Impacts
- Wetland Impacts

General Questions

Q: What are the ecological effects of the oil spill?

Short Answer: The oil will affect ecological resources through toxicity (primarily the aromatic, volatile components of the oil), coating of plants and animals, and through direct ingestion of the oil sheen, mousse (oil/water mixture), or tar balls. The potential impacts may be greater given the particular season in which this spill is occurring. Many of the animals along the Gulf Coast, including fish and birds, are spawning and reproducing at this time. Coastal wetlands in Louisiana and Mississippi provide the critical breeding grounds and nurseries for 90% of marine species in the Gulf of Mexico.

Detailed Answer: The most immediate affect is in the offshore waters. The oil would come in contact with the microscopic plankton (which are tiny plants, known as phytoplankton and small animals including eggs and larvae of fish and macroinvertebrates, called zooplankton) in the surface waters, and fish, turtles, and marine mammals. The plankton form the base of the food web that supports marine species. Any impacts on this food base may affect the entire marine ecosystem.

Breeding season brings fish and other aquatic animals (sea turtles, birds, etc.) into shallow water, increasing the potential risk to them. It also makes shoreline associated birds and other wildlife less likely to flee the oncoming oil, given their desire to maintain the reproductive seasonal territory many have just claimed.

We are already seeing impacts on marine turtles which may think the oil is food and ingest the tar balls. The Mississippi barrier islands and Chandeleur barrier islands are major nesting and breeding areas for sea turtles. Endangered and threatened species that could be impacted include the West Indian manatee, five baleen whales (the northern right, blue, fin, sei,and humpback), one toothed whale (the sperm whale), Gulf Sturgeon, Smalltooth Sawfish, Dusky, Night and Tiger Sharks, Nassau and Warsaw Grouper, and five species of sea turtles (the Green, Hawksbill, Kemp's Ridley, Leatherback, and Loggerhead).

Q: How will the oil spill affect marine organisms?

Short Answer: The toxicity of petroleum on marine organisms is dependent upon the concentration and composition of its individual hydrocarbons at the time of impact. Since most oils float, the creatures most affected by oil are animals like sea otters and seabirds that are found on the sea surface, or on the surface of beaches if the oil comes ashore. During most oil spills, seabirds are harmed and killed in greater numbers than other kinds of creatures.

Detailed Answer: The relative impact of the oil will shift as spilled oil weathers due to the change in its chemical composition. Because the oil is being released such a distance from shore and at such depth, it is anticipated that the oil will undergo significant weathering before reaching shoreline areas. Sea conditions will weather the oil, as the more water soluble compounds tend to be "extracted" from the oil, leaving the less soluble and more viscous compounds to continue to coalesce on the water surface. The more viscous nature of the oil can have deleterious effects by causing coating of marine organisms and the tar balls that form may be mistaken for food.

The use of dispersants offshore will lessen the potential impact of the oil onshore, however it may increase the risk for water column toxicity in the areas where the dispersants are being used. Generally, dispersants are used in deeper waters, which allow aquatic life the opportunity to flee from the plume of dispersed compounds. Using dispersants in shallow water can exacerbate some of the aquatic toxicity of the spilled oil (e.g., it solubilizes chemicals contained in the oil) and therefore they are not often recommended for use in shallow waters.

Q: What would be most affected by the oil spill along shorelines, bays, and estuaries?

Short Answer: It is anticipated that the majority of the negative impacts of the oil as it approaches the shore and makes landfall will be the physical effects of the oil on the plants, animals, and nursery grounds (wetlands, marshes and mangroves) with which it comes into contact. The oil could coat the marsh plants and estuarine organisms and may be toxic if there are any aromatic compounds that haven't evaporated and are still in the oil. The degree of impact will be highly dependent upon the type of shoreline that is affected.

Detailed Answer: These bays and estuaries are the nursery grounds for numerous fish and shrimp species. In fact, 90% of the marine fish and shellfish are estuarine-dependent. The greatest concern is for these critical shallow water habitats. Also among the most significant potential impacts from the spilled oil as it travels toward shore will continue to be the potential for oiling of marine mammals and seabirds as long as the oil is being released. *Wetlands and marshes* are fairly fragile and very biologically active habitats, therefore the physical effects of fouling and coating of these environments are also expected to be significant. Much of the aforementioned shorelines, especially for Louisiana, Mississippi and Alabama, contain these types of habitats. *Marshes* are great nursery areas for larval and juvenile fish and other aquatic organisms, as they provide cover and food resources. If substantial areas of the coastal marshes are severely altered or impaired by the oil, this could have significant and long term effects on the populations of the fish, shrimp and related animals that use these areas. *Mangrove* roots are exposed to obtain oxygen, and when they are coated with oil the plants generally do not survive. It is not known how much of the shorelines of Louisiana, Mississippi, Alabama and the panhandle of Florida contain mangroves, but these are usually very productive and highly valued ecosystems. Petroleum and its by-products may injure and kill mangroves in a variety of ways. Crude oil coats roots, rhizomes, and pneumatophores and disrupts oxygen transport to underground roots. As with other intertidal communities, many of the invertebrates, fishes, and plants associated with the mangrove community are highly susceptible to petroleum products.

The spill may impact the brown shrimp (shrimp is the most valuable commercial species in the Gulf). They spawn on the bottom of the offshore waters. Their larvae then float to the surface and move into the marshes, which serve as a nursery until they get big enough to go back to their offshore bottom habitat. Currently, they are in the post-larval stage and beginning to enter the marsh nurseries.

Another significant impact is on the birds (see Marine and Coastal Birds Q & A). This spill is occurring at the height of the nesting season for many marsh and wading birds. The birds would be impacted by ingesting the tar balls mistaking them for food, getting coated with oil and eating oil contaminated fish.

The oil could also impact oysters which are currently spawning. Oysters also filter large volumes of water increasing exposure to the oil. The oil could persist in the marsh and open water sediments and impact aquatic organisms for quite some time.

Endangered and threatened species along the shorelines, bays, and estuaries include the inflated heelsplitter, bald eagle, piping plover, and West Indian manatee (see Threatened and Endangered Species Q & A).

Q: What are some long-term effects of oil spills?

Short Answer: Oil remains in the environment long after a spill event, especially in areas sheltered from weathering processes, such as the subsurface sediments under gravel shorelines, and in some soft substrates. Oil spills may also cause shifts in population structure, species abundance and diversity, and distribution. Habitat loss and the loss of prey items also have the potential to affect fish and wildlife populations.

Detailed Answer: Plant communities in coastal ecosystems have different susceptibilities to contamination. In temperate regions, salt marshes are most vulnerable. Many salt marsh plants are relatively short, measuring up to three feet in height. Because they are low, salt marsh plants can be completely covered by the oil after a spill causing dieback. This can influence the stability of the soil in wetland hammocks, causing erosion and loss of wetland habitat.

Q: Why does it take so long for oil spills to be cleaned up along the shoreline?

Short Answer: The degree of impact, and thus clean-up, will be highly dependent upon the type of shoreline that is affected. Sandy shore lines are relatively easy to clean, and the impacts from oil on the shore lines is usually not overly significant in a relative sense because the oil can be cleaned up in a reasonable timeframe once the source is stopped, and many of these types of shorelines are not as biologically active as areas such as marshes. Impacts to coarse substrate shorelines would be more difficult to mitigate than for a fine sandy beach, simply due to the fact that the oil could penetrate further into a course substrate, and therefore cleanup efforts would have to be more extensive. It is very difficult to clean wetlands and marshes once they have been oiled. The options for cleaning the wetlands and marshes depend on a variety of factors. If the oil reaches beyond the grassy vegetation and gets to the sediments, however, options are very limited.

Detailed Answer:
Digging up the wetlands to remove the oil can oftentimes cause more harm than leaving the oil in place. Natural processes such as wave action to remove the oil are often not very effective, because the wetlands are usually in fairly quiescent areas which limit the amount of wave action. It should be noted that heavily oiled seagrass beds may die immediately upon contact with the oil. Seagrasses could be spared, although leaves may turn brown and become heavily covered by algae for several months. This type of impact was seen following the spill in Panama.

Q: How will the oil spill affect the hypoxic zone in the Gulf?

Short Answer: Decaying wetland plant material from oil contamination may be released into the coastal ocean. The organic materials and oxygen demand may contribute to oxygen consumption and the hypoxic zone along the continental shelf.

Detailed Answer: Summer is the season that the Gulf of Mexico hypoxic zone sets up, generally flowing westward from the Mississippi River plume. The phenomenon results in low dissolved oxygen in bottom waters. Coastal currents generally flow westward during winter/spring, but reverse during late spring and summer and flow eastward. The oil spill is moving towards the hypoxic zone and any decaying plant or animals resulting from the oil spill, whether in coastal waters or dead material from coastal marshes deposited by tides could exacerbate the hypoxic zone.

Biological Impacts

Q: How will the oil spill affect the open ocean food web?

Short Answer: The phytoplankton form the base of the food web that supports marine species. Any impacts on this food base may affect the entire marine ecosystem. The impact on the phytoplankton will depend on how long the oil persists as they have short life spans, new phytoplankton can be recruited from other areas, and they move up and down in surface waters.

Detailed Answer:. Phytoplankton and zooplankton, critical components to the marine ecosystem, have demonstrated different reactions to oil. Larvae stages of the fish life cycle are more susceptible to acute biological loss. Fish eggs and larvae are vulnerable to oil damage in the open water environment as they float along.

Q: What animals offshore will be affected by the oil spill?

Short Answer: Any animals that have to go to the surface to breathe (turtles, whales, dolphins, and seals) and small animals such as marine birds, lantern fish (which move up to surface waters to feed at night), amphipods, jellies, invertebrate eggs and larvae may be negatively affected by the oil spill.

Detailed Answer: Larvae stages of the fish life cycle are more susceptible to acute biological loss. Fish eggs and larvae are vulnerable to oil damage in the open water environment as they float along. Fish can be impacted directly through uptake by the gills, ingestion of oil or oiled prey, effects on eggs and larval survival, or changes in the ecosystem that support the fish. Marine birds which spend much time on the sea surface (e.g. shearwaters, cormorants, seaducks, and alcids) are especially vulnerable to oil spills. Larger pelagic animals such as medium-sized fish and squids, may swim into the plumes and back out again. Offshore oil spills could also have a serious impact on juvenile turtles. Sea turtles and marine mammals must surface to breathe and could contact surface oil slicks. Some evidence indicates that sea turtles, especially juveniles, are transported by passive drift and are associated with density associated with density shear lines and sargassum weed. This could prolong their exposure to a large oil slick transported in the same manner. Threats to whales and dolphins are at much more risk at the surface (from inhalation of volatiles and direct contact with slicks) than they would be from diving through dispersed oil in deep water or consuming squid that may be exposed to deep water dispersed oil plumes.

Q: Shrimp and oysters are spawning this time of year, how will the oil spill affect them?

Short Answer: If the oil finds its way into the marshes, shrimp mortalities will be high. If exposed to oil, oysters will react by dedicating their energy resources to survival, rather than to reproduction.

Detailed Answer: Brown shrimp are now in the post-larval stage, beginning to enter the estuaries, and are vulnerable to volatile aromatic hydrocarbons, which are soluble in water. For oysters, if they do succeed in reproducing but the cultch is oiled, the spat will not set and reproductive success could be jeopardized next year and possibly beyond. Oysters also filter large volumes of water increasing exposure to the oil. The oil could persist in the marsh and open water sediments and impact aquatic organisms for quite some time.

Q: What marine fish and invertebrate species are most likely affected by the oil spill in the Gulf?

Short Answer: Pelagic fish species that migrate to the Gulf to spawn, as well as the marine fish and invertebrate species in the pelagic egg and larval stages are most likely to be affected.

Detailed Answer: There are many pelagic fish spp that frequent the Gulf in the spring, summer and fall. Of particular concern are those species that migrate to the gulf to spawn.

Several high value commercial and recreational pelagic (tunas, dolphinfish, cobia,) spawn in the Gulf waters. Bluefin tuna in particular may be of higher concern since spawning has been detected in only two areas: the Mediterranean and Gulf of Mexico. Little is known about the spawning of bluefin, as it has not been observed. Spawning in the Gulf of Mexico occurs from April to June. Differences in timing could be due to any of a number of factors, such as differing environmental cues or genetic variation. In the Gulf of Mexico, spawning occurs at temperatures of 76.8 to 85.1 °F(24.9 to 29.5 °C). Average females produce up to 10 million eggs per year. Their eggs are buoyant, and are distributed a considerable distance by the surface currents. Since they have buoyant eggs, this may be an issue depending on where the spawning pods are and where the oil slick is. Both chemical toxicity and physical smothering of eggs and icthyoplankton (larval fish) may occur. This type of impact is also a concern for other tuna species and other pelagic fish with this reproductive strategy. The majority (nearly all) of commercially valuable marine fish and invertebrate species, as well as the forage species they feed on, have pelagic egg and larval stages and that includes ground fish and demersal species as well as pelagics. They are all equally vulnerable to oil exposure during these early life stages.

Fortunately fish/invertebrate eggs are just marginally less dense than median seawater and a host of factors influencing the actual density of seawater, water currents, and density of eggs determines their vertical and horizontal distribution in the ocean. They are not trapped on the surface where most of the oil is concentrated. That will limit oil exposure. Larvae will move under their own power throughout the water column and also distributed according to where prey is located. They are not concentrated at the surface. Nor are they expected to be concentrated in the area of the oil spill. These assemblages are very patchy spatially both vertically and horizontally. Deepwater fish that live near the bottom (demersal) may be more likely to be at risk if small tar aggregates can settle as sea snow. The Mississippi Trough and Canyon are home to one of the most abundant and diverse communities of deep sea fishes, due to influx of nutrients from the Mississippi River. Species richness is highest on the upper slope and decreases with depth. The deep sea fishes tend not to be the commercial or recreational species.

Q: How will oil affect the invertebrate community?

Short Answer: Oil can have acute and chronic effects on inshore and offshore marine invertebrate communities when oil becomes concentrated along the shoreline causing sediments to serve as reservoirs for the spilled oil, and for pelagic species during early or adult stages when they are exposed to surface waters.

Detailed answer: There are both offshore marine and inshore invertebrate communities to consider. Offshore invertebrates can be exposed at the surface for those species that may be pelagic during early or adult stages. Benthic communities may be exposed as chemical dispersants and normal weathering causes oil to be deposited on the seafloor. Benthic invertebrate communities include soft (mud and sand) and hard bottom communities common in the GOM. Persistent aromatic hydrocarbons and heterocyclic compounds and their breakdown products can linger in sediments for long periods causing toxicity to marine polychaetes and other invertebrates that live in sediments.

Oil can be directly toxic to marine invertebrates or impact them through physical smothering, altering metabolic and feeding rates, and altering shell formation. These toxic effects can be both acute (lethal) and chronic (sub-lethal). Intertidal benthic (bottom dwelling) invertebrates may be especially vulnerable when oil becomes highly concentrated along the shoreline. Additionally, sediments can become reservoirs for the spilled petroleum. Some benthic invertebrates can survive exposure, but may accumulate high levels of contaminants in their bodies that can be passed on to predators. The coastal subtidal zone (underwater at all times) and intertidal zone (covered only during high tide) are inhabited by multiple small invertebrates. The fiddler crab, a species that inhabits the intertidal zone, is regarded as the "canary in a coal mine" for oil spills. This invertebrate is present in the estuarine habitats around the world and is therefore a universal indicator for the impact of oil spills on coastal ecosystems. As with other organisms, fiddler crabs exhibit dose response mortality due to oil toxicity. Thus the status of the fiddler crab population in an area after an oil spill is a sensitive marker for the severity of the spill.

Q: What are the possible effects of the crude oil on the fish community?

Short Answer: Fish can be impacted directly through uptake by the gills, ingestion of oil or oiled prey, effects on eggs and larval survival, or through changes in the ecosystem that support the fish.

Detailed Answer: Adult fish may experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion, and reproductive impairment when exposed to oil. Fish exposed to sublethal concentrations can display elevated liver enzymes involved in detoxification. Destruction of the estuarine and marsh habitat used for spawning and nursery grounds may have a big impact on both inland and offshore fish communities. Oil has the potential to impact spawning success, as eggs and larvae of many fish species, are highly sensitive to the toxic constituents of crude oil.

Marine Mammals

Q: What affects will the oil spill have on whales, dolphins, and seals (marine mammals)?

Short Answer: Marine mammals are at much more risk at the surface (from inhalation of volatiles and direct contact with slicks) than they would be from diving through dispersed oil in deep water.

Detailed Answer: Fresh crude oil releases toxic vapors that when inhaled may irritate or damage respiratory membranes, congest lungs, and cause pneumonia. Following inhalation, volatile hydrocarbons may be absorbed into the bloodstream and accumulate in the brain and liver, leading to neurological disorders and liver damage (Geraci and St. Aubin, 1982; Geraci, 1990). Toxic vapor concentrations may occur just above the surface of an oil spill and, thus, may be available for inhalation by surfacing cetaceans. For whale and dolphins (and probably sirenians as well), direct contact of oil may irritate, inflame, or damage skin and sensitive tissues (such as eyes and other mucous membranes). Prolonged contact to petroleum products may reduce food intake; elicit agitated behavior; alter blood parameters, respiration rates, and gas exchange; and depress nervous functions. Under less extreme exposures (lower concentrations or shorter durations), oil does not appear to readily adhere to or be absorbed through cetacean skin, and may actually provide a barrier to the uptake of oil-related aromatic hydrocarbons through the body surface. The most likely effects of oil on marine mammals are: (a) a mild deleterious but reversible effect on the skin; (b) possible eye irritation, which would be reversible unless exposure is prolonged; (c) possible short-term baleen fouling with possible feeding reduction; (d) possible blowhole fouling and death due to respiratory stress for very young animal in heavy oil; and temporary food reduction or contamination, and oil ingestion.

Q: What if marine mammals consume food that is contaminated with oil?

Short Answer: Marine mammals may incidentally ingest floating or submerged oil or tar and may consume oil-contaminated prey. Ingested oil can remain within the gastrointestinal tract and be absorbed into the bloodstream.

Detailed Answer: Marine mammals may incidentally ingest floating or submerged oil or tar and may consume oil-contaminated prey. Spilled oil may also foul the baleen fibers of mysticete whales, temporarily impairing food-gathering efficiency or resulting in the ingestion of oil or oil-contaminated prey. Ingested oil can remain within the gastrointestinal tract and be absorbed into the bloodstream and, thus, could irritate and/or destroy epithelial cells in the stomach and intestine. Certain constituents of oil, such as aromatic hydrocarbons and polyaromatic hydrocarbons, include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms.

Marine and Coastal Birds

Q: How will the oil slick affect marine and coastal birds?

Short Answer: Marine birds which spend much time on the sea surface are especially vulnerable to oil spills. Birds may be adversely affected through direct contact with the spilled oil, by the fouling of their habitats and contamination of their food by the oil, and as a result of oil-spill response activities.
Direct contact by birds with oil of appreciable amounts is usually fatal. Diving birds and underwater swimmers such as loons, cormorants, and diving ducks may be the most susceptible to spilled oil because of their relatively long exposure time in the water and at the sea surface. Also, many of these birds nest and roost on barrier islands and beaches and are at risk if oil comes ashore or affects their food sources.

Detailed Answer: Birds may become fouled with oil by diving through oil slicks to capture prey, or by wading and walking through contaminated areas, then preening feathers and ingesting the oil. Mortality results primarily from hypothermia as oil mats the plumage

destroying the thermal barrier. Ingested oil may depress egg laying activity or may result in the death or deformities of young coastal birds. Additionally, abnormalities in bird reproduction physiology and behavior resulting from ingestion of oil potentially could have substantial adverse effects on egg production in seabird and water fowl populations.
Some species have begun nesting or building pair bonds in preparation for nesting. Many exhibit low reproductive rates and a disruption to their breeding cycle this year could have serious effects on the population for years to come. They feed on fish and other estuarine organisms, such as small invertebrates or oysters. If these food sources become contaminated, lethal and sublethal toxic and physiological effects or starvation from the reduction of food resources could occur. Finally, oil-spill response activities may disturb birds in the affected habitat as well as nearby habitats that are unaffected by an oil spill.

Threatened or Endangered Species

Q: What threatened or endangered species are in the Gulf region?

Short Answer: Some endangered species in the Gulf region include whales, fish, turtles, and coastal and marine birds.

Detailed Answer: The West Indian manatee, five baleen whales (the northern right, blue, fin, sei,and humpback), one toothed whale (the sperm whale), Gulf sturgeon, Smalltooth Sawfish, Dusky, Night and Tiger Sharks, Nassau and Warsaw Grouper, and five species of sea turtles (the Green, Hawksbill, Kemp's Ridley, Leatherback, and Loggerhead) are some of the endangered species at risk in this oil spill.

Q: How will the oil spill affect sea turtles?

Short Answer: The oil spill can have a serious impact on sea turtles as the turtle surfaces to breathe and as the oil spill goes ashore on the sandy beaches the turtles use to deposit their eggs in. A large spill could affect many more individuals and habitats, including nesting beaches, and potentially may incur population-level effects.

Detailed Answer: Hatchling and juvenile turtles feed opportunistically at or near the surface in oceanic waters, and may be especially vulnerable and sensitive to spilled oil and oil residues such as floating tar. Some evidence indicates that sea turtles, especially juveniles, are transported by passive drift and are associated with density associated with density shear lines and sargassum weed. This could prolong their exposure to a large oil slick transported in the same manner.
Ingested oil, particularly the lighter fractions, could be toxic to sea turtles. Ingested oil may remain within the gastrointestinal tract, irritate and/or destroy epithelial cells in the stomach and intestine, and subsequently be absorbed into the bloodstream (NOAA, 2003). Certain constituents of oil, such as aromatic hydrocarbons and PAHs, include some well-known carcinogens. Sea turtles and marine mammals must surface to breathe and could contact surface oil slicks inhaling petroleum vapors and aspirating small quantities of oil. While no

information is available regarding the effects of petroleum vapors or aspirated oil on sea turtles, inhalations by mammals of small amounts of oil or petroleum vapors have been shown to result in acute fatal pneumonia, absorption of hydrocarbons in organs and other tissues, and damage to the brain and central nervous system. Tar found in the mouths of turtles may have been selectively eaten or ingested accidentally while feeding on organisms or vegetation bound by tar. Sea turtles exposed to oil or tar balls have been reported to incur a variety of conditions, including inflammatory dermatitis, breathing disturbance, salt gland dysfunction or failure, hematological disturbances, impaired immune responses, and digestive disorders or blockages.

Because most sea turtles nest above the high-tide line, and oil washing ashore would be deposited at and just above the high-tide line, oiling of actual nests is unlikely except possibly in the event of exceptionally high tides or storms. However, hatchlings may become oiled while traveling from the nest to water, and a heavy oil layer or tar deposits on the beach may prevent the hatchlings from reaching water. If exposed hatchlings reach the water, they may have difficulty swimming, increasing the potential for predation. Nesting adults (females) may also be exposed while coming ashore on oiled beaches. Impacts on the quality or quantity of foraging or nesting habitats could result in population level effects.

The magnitude and severity of impacts that could result from such exposures would depend on the location of the spill, spill size, type of product spilled, weather conditions, the water quality and environmental conditions at the time of the spill, and the species and life stage of the sea turtle exposed to the spill.

Q: Will the oil spill affect manatees?

Short Answer: The West Indian manatee would be most vulnerable to a spill as it occurs in marine, estuarine, and freshwater river systems and canals where it congregates.

Detailed Answer:

The West Indian manatee range freely between marine and freshwater habitats along coastal Florida, Alabama, Mississippi, Louisiana, and Texas, and, therefore, could be exposed to the oil spill. They eat both submerged (e.g. seagrass) and floating vegetation and could be impacted if these food sources are contaminated or large stands of seagrass die from oil exposure. Impacts to the manatee population could be significant due to population decreases from the cold winter in Florida.

Wetlands

Wetland Impacts from Oil Spill
Questions and Answers

Q: How will oil affect the wetland region of the Gulf and why are people concerned?

Short Answer: Oil spills may cause shifts in wildlife and plant population structures, species abundance, diversity and distribution, as well as erosion and loss of wetland habitats resulting

from possible dieback of salt marsh plants. Southern Louisiana contains 40% of the wetlands found in the lower 48 states. The bays and estuaries are the nursery grounds for numerous fish and shrimp species. In fact, 90% of the marine fish and shellfish are estuarine-dependent. The greatest concern is for these critical shallow water habitats. The seafood production from the Gulf of Mexico exceeds that of all the areas of the east coast from Maine to Florida, combined. Louisiana accounts for almost 80% of that Gulf production. Recreational fishing pumps billions of dollars into regional economies each year (Louisiana - $757 million).
Detailed Answer: Habitat loss has the potential to affect fish and wildlife populations. Oil remains in the environment long after a spill event, especially in areas sheltered from weathering processes, such as the subsurface sediments under gravel shorelines, and in some soft substrates. Plant communities in coastal ecosystems have different susceptibilities to contamination. In temperate regions, salt marshes are most vulnerable. Many salt marsh plants are relatively short, measuring up to three feet in height. Because they are low, salt marsh plants can be completely covered by the oil after a spill causing dieback. This can influence the stability of the soil in wetland hammocks, causing erosion and loss of wetland habitat.

Aquatic organisms that feed on detritus in shallow coastal waters, such as shrimp, blue crabs and filter feeders such as mussels and oysters, could be impacted by exposure to small particles of tar suspended in the water column and sinking to the bottom. Wildlife inhabiting coastal marshes can become exposed to contamination accumulating in their food supply. Wading birds, such as herons, egrets, ibis, clapper rails, and wood storks, and mammals such as raccoons could become exposed to oil-related polycyclic aromatic compounds through the foodchain.

The coastal wetland ecosystem not only produces seafood but provides natural filtration, and cleanses water of pollution and contaminants. These wetlands protect our coastal communities from natural disasters. Every mile of wetlands can reduce storm surge by as much as a foot. That means billions saved in lost property. All these valuable contributions to our health and well being are at risk by what could be one of the most significant oil spills ever in our coastal waters.

Q. What will be the impacts of the Deepwater Horizon spill to the coastal wetlands and what factors influence those impacts?

Short Answer: We cannot predict the specific impacts with certainty because it is unknown as to where the oil spill will come ashore, but we do have a basic understanding of the potential effects that oil can have on wetland plants and soils. Critical to better understanding the impact of the oil spill on wetlands will be knowledge of the following: 1) type of oil, 2) direction oil spill is headed and projected landfall, 3) wetland types projected to be impacted by oil spill, and 4) wetland plant species sensitivity to oil contamination.

Detailed Answer: There is considerable uncertainty about the present and future quantities of oil released, the actual make up of the oil, its anticipated trajectory of impact, the effect of projected use of deep water dispersants, and future meteorological conditions. Anticipated outcomes could change dramatically as new data becomes available. Because the oil is being released such a distance from shore and at such depth, it is anticipated that the oil will undergo significant weathering before reaching shoreline areas. Sea conditions will weather the oil, as the more water soluble compounds tend to be "extracted" from the oil, leaving the less soluble and more viscous compounds to continue to coalesce on the water surface.

The level of impact to coastal wetlands by oil is influenced by a number of factors, including: 1) type (i.e., toxicity and viscosity properties) and amount of oil, 2) plant species' sensitivity, 3) extent of oil coverage on vegetation and marsh surface, 4) season of the spill, 5) weather conditions, and 6) soil composition (i.e., soil organic matter influences penetration and sorption of oil; soils with high soil organic matter may be of particular concern; soil texture can also potentially affect residual oil concentrations). Increasing our understanding of these various factors will help us to better anticipate what coastal wetland impacts can be expected.

Q: Where are the areas being impacted, how will those different wetland/shoreline types be impacted and what are the clean up options?

Short Answer: Although it is difficult to identify the exact locations where the oil will come ashore, there are very large expanses of marshes in the Pass A Loutre Wildlife Management Area and the Delta National Wildlife Area in the eastern portion of the Mississippi River Delta of Louisiana that appear to be in the path of a oil spill landfall. We also know that should it reach the Mississippi River Gulf Outlet, this could provide the oil spill ingress to additional expanses of those marsh habitats, both emergent scrub-shrub, and forested wetlands. The degree of impact will be highly dependent upon the type of shoreline or marsh physiography and substrate that is affected. The following are examples of different wetland and shoreline types, their sensitivity to oil spills and potential clean-up scenarios. Options for cleaning or removing oil from wetlands areas are very limited. It is possible, depending on the type of oil and potential for other environmental effects, that the best option would be to allow for the natural attenuation of the oil. The goal should be to minimize damage from the cleanup effort itself. Too many people and machines mucking about could seriously compound the damage. The rule of thumb should be to place top priority on maintaining the physical and chemical integrity of the habitat, so the organisms will have an opportunity to repopulate. Treat the marshes gently.

Detailed Answer: Potentially, other areas of Louisiana including the Chandeleur Islands within the Breton National Wildlife Refuge, Breton Sound, Chandeleur Sound, and the highly fragmented marshes of Plaquemines and St. Bernard Parishes may also be affected. In addition for Mississippi, once in Breton Sound, oil could move into Mississippi Sound and onto western Mississippi barrier islands and shorelines. Oil could also move in a westerly direction into Lake Borgne and Lake Pontchartrain, due to the broken marsh topography, expanse of open water, and meteorological influences. There are also areas of coastal Mississippi, Alabama, and the panhandle of Florida that could be affected, including marshes and possibly mangroves.

Wetlands are fairly fragile and very biologically active habitats, therefore the physical effects of fouling and coating of these environments are expected to be significant. It is very difficult to clean wetlands once they have been oiled. The options for cleaning the wetlands depend on a variety of factors. If the oil reaches beyond the grassy vegetation and gets to the sediments, however, options are very limited. Digging up the wetlands to remove the oil can oftentimes cause more harm than leaving the oil in place. Natural processes such as wave action to remove the oil are often not very effective, because the wetlands are usually in fairly quiescent areas which limit the amount of wave action. It should be noted that heavily oiled sea grass beds may die immediately upon contact with the oil and entire intertidal beds of sea grasses may be killed. Sub-tidal sea grasses could be spared, although leaves may turn brown and become heavily covered by algae for several months.

Marsh plants may survive being oiled, unless the majority of the plant is covered, including roots and stems. If incident response personnel are walking or moving equipment throughout the marshes, compacting the substrate and uprooting plants, holes could open up where open water could replace marsh. To the degree possible, it would be advantageous to restrict response vehicles, equipment, and personnel to established waterways. Consideration should be give to placing booms outside of the marsh edges. If oil floods further into the marsh, attempts could be made to skim or absorb oil on the ebb, or outgoing, tide.

These specific wetland/marsh types can be found along the area of potential impact:

Sandy Tidal Flats

The sandy tidal flat classification is used to describe shoreline types comprised of broad intertidal areas consisting of fine and coarse grain sand and minor amounts of shell hash. The mean grain size ranges between 0.0625 mm and 0.4 mm. Sandy tidal flats are typically found in association with barrier island and tidal inlet systems. Sandy tidal flats are submerged during each tidal cycle. At low tide, a typical sandy tidal flat may be 100-200 m wide. The most common sandy tidal flat occurrences are associated with flood-tidal deltas, recurved spits, and back barrier areas. Salt marsh vegetation often develops along the upper intertidal areas of sand flats. Due to the low tidal flat gradient, slight changes in water levels can produce significant shoreline changes. Low water levels can expose extensive tidal flat areas to oiling.

Sandy Tidal Flats Environmental Concerns

- **Sensitivity:** The environmental sensitivity of sandy tidal flats is moderate due to the presence of wetland habitat.

- **Oil Behavior:** Oil typically stains and covers sediment and vegetation with low to moderate sediment penetration.
- **Cleanup:** The oil penetration potential is low/moderate depending on the water level and the location of oil deposition. The transitability of sandy tidal flats is moderate/good depending on substrate character. Major environmental concerns related to cleanup include the protection and cleanup of wetland habitat and further subsurface contamination due to trampling and equipment movement. Tidal flat access in Louisiana is typically poor.

Muddy Tidal Flat

The muddy tidal flat classification is used to describe shoreline types comprised of broad intertidal areas consisting of mud and minor amounts of shell hash. The grain size is finer than 0.0625 mm. Muddy tidal flats are typically found in association with prograding river mouths. Muddy tidal flats are soft, dynamic shorelines rich in newly developing habitat. Mudflats located at prograding river mouths are vegetated by willow tree and sugar cane swamps. Prograding mudflats on the coast are vegetated by lush growths of salt marsh.

Muddy Tidal Flats Environmental Concerns

- **Sensitivity:** The environmental sensitivity of muddy tidal flats is high due to presence of developing wetland habitat. Oil usually coats and covers sediment and vegetation.
- **Oil Behavior:** Oil typically stains and covers sediment and vegetation.
- **Cleanup:** The sediment penetration potential is low due to the high water table and water content in the sediment. The major environmental concern associated with muddy tidal flats is the damage done by the cleanup of wetland habitats as well as their protection from cleanup operations. Both access and transitability of muddy tidal flats is poor. The potential exists for further contamination of subsurface sediments due to trampling and equipment movement.

Swamps

The swamp classification describes shoreline types that are comprised of scrubs, shrubs, evergreen trees, and hardwood forested wetlands. This shoreline type is essentially a flooded forest. This shoreline type is common in the river valleys of the chenier plain, and the interior areas of the delta plain. The sediments within the interior swamps tend to be silty clay and contain a large amount of organic debris.

Swamps Environmental Concerns

- **Sensitivity:** The environmental sensitivity is high for swamps because of the presence of wetland habitat.
- **Oil Behavior:** Oil usually coats and covers the sediment and vegetation with low sediment penetration.
- **Cleanup:** The sediment penetration potential is low due to the high water table and the water content of the sediments. A major environmental concern is that the cleanup may

be more damaging than the oil itself. The access and trafficability of swamps are poor due to the soft sediment and the presence of dense tree growth.

Fresh Marshes
The fresh marsh classification is used to describe shoreline types found in the coastal interior. Freshwater marshes include floating aquatic mats, vascular submerged vegetation, needle and broad-leaved deciduous scrubs and shrubs, and broad-leaved evergreen scrubs and shrubs. The sediments are highly organic and muddy. Fresh marshes are characterized by high biodiversity and rich wetland habitat. This shoreline type is found within the river valleys that dissect the chenier plain as well as between the individual ridges. On the delta plain, freshwater marshes occur in the upper reaches of individual delta complexes as well as along distributary courses.

Fresh Marsh Environmental Concerns

- **Sensitivity:** The environmental sensitivity of fresh marshes is high because of the presence of wetland habitat.
- **Oil Behavior:** Oil usually coats and covers the sediment and vegetation with low sediment penetration.
- **Cleanup:** The sediment penetration potential is low due to the high water table and water content of the sediments. A major environmental concern about fresh marsh is that the cleanup can be more damaging than the oil itself, left alone. Transitability of fresh marsh is poor due to the soft sediment. Access is typically poor in Louisiana.

Salt Marshes
The saltwater marsh classification describes shoreline types that are wet grasslands vegetated by salt-tolerant species. This shoreline type includes saline, brackish, and intermediate marsh types. Saltwater marshes are extensive throughout the outer fringe of the Chenier and delta plains.

Salt Marsh Environmental Concerns

- **Sensitivity:** The environmental sensitivity is high for salt marsh because of the presence of wetland habitat.
- **Oil Behavior:** Oil usually coats and covers the sediment and vegetation with low sediment penetration.
- **Cleanup:** The sediment penetration potential is low/moderate due to the high water table and water content of the sediment. A major environmental concern is that the cleanup may be more damaging than the oil itself. The transitability of salt marsh is poor. Access is typically poor in Louisiana.

Q: How will the oil spill impact marsh plants, mangroves, or other wetland aquatic plants?

Short Answer: The tarry residue that will make it to shore lines will likely cover whatever it touches and can cause smothering of wetlands and marshes.

Detailed Answer: The greatest negative impact to wetlands/marshes/swamps is anticipated to occur for marsh plants and mangrove shorelines. Petroleum hydrocarbons impact plants in several ways including disruption of plant-water relationships, direct impacts to plant metabolism (e.g. nutrient uptake), toxicity to living cell (e.g. chloroplast membrane), and reducing oxygen exchange between atmosphere and soil (impact root function). Although much of the lighter and more water soluble fraction of the oil is anticipated to have been weathered from the land-falling crude, which should ameliorate the chemical toxicity hazards somewhat, the weathered crude is likely to coat whatever it touches. Species sensitivity maybe related to the effect of oil on photosynthetic rate, live and dead biomass, plant-stem density, plant re-growth year after spill. One of the primary reasons for plant dieback is a result of death of underground rhizomes. Deeper penetration of oil could result in higher mortality of plants. *Spartina patens* are shallow rooted species and are more susceptible to subsurface oil contamination.

Q: What are the impacts of oil penetrating soils and sediments?

Short Answer: The penetration of oil into the soil/sediments has the potential to cause acute and chronic plant damage. The deeper penetration of oil could result in higher mortality of plants.
Detailed Answer: Acute and chronic plant damage can include reduced stem height, reduced plant density, reduced aboveground biomass, and mortality. If the oil impacting the wetlands is relatively thick oil, it could cause physical smothering of the sediments, sediment dwelling organisms including eggs that have been laid, and the wetland plants.

Q: How will beaches be impacted?

Short Answer: The degree of impact on beaches resulting from the oil spill will be highly dependent upon the grain size of the beach substrate.
Detailed Answer: Traditionally, sandy shore lines are relatively easy to clean, and the impacts from oil on the shore lines is usually not overly significant in a relative sense because the oil can be cleaned up in a reasonable timeframe once the source is stopped, and many of these types of shorelines are not as biologically active as areas such as marshes. Shore lines with coarser substrate such as gravel or cobble also are able to be cleaned to a large degree, and therefore the impact of the shorelines are not anticipated to be exceptionally long-lived once the source of the oil has been stopped. Impacts to coarse substrate shorelines would be more difficult to mitigate than for a fine sandy beach, simply due to the fact that the oil could penetrate further into a course substrate, and therefore cleanup efforts would have to be more extensive.

Q: Can dispersants be used in wetland areas?

Short Answer: The use of dispersants offshore will lessen the potential impact of the oil onshore, however it may increase the risk for water column toxicity in the areas where the dispersants are being used.
Detailed Answer: Generally, dispersants are used in deeper waters, which allow aquatic life the opportunity to flee from the plume of dispersed compounds. Using dispersants in shallow

water can exacerbate some of the aquatic toxicity of the spilled oil (e.g., it solubilizes chemicals contained in the oil) and therefore they are not often recommended for use in shallow waters. Estuarine use of dispersals must be approved by the Regional Response Team.

Dispersants have been pre-approved for use in ten meters of water or deeper. Much of the targeted Louisiana estuarine area is significantly shallower than that, with less wave energy than situations in which dispersants have previously been employed.

In order to be effective, dispersants require energy, such as wave energy, to mix them through the oiled surface waters. Breaking the oil into droplets increases the surface area and facilitates the biodegradation of the hydrocarbons. In extremely shallow nearshore environments along the Gulf coast, adequate mixing energy may be lacking. Oil dispersants have been proven in deeper, higher energy marine environments but could "disperse" or transport oil throughout a vastly broader area and into more ecologically sensitive areas of the delta and nearby bays. Dispersants may not be completely benign in an estuarine environment. They might prove to be toxic or at least act as an ecological stressor to oysters, shrimp, and larval fish in the intertidal zone. This might be all the more significant during the spring spawning season.

Q: Is chemical toxicity a concern for wetlands?

Short Answer: Again, some chemical toxicity would be expected, but the main effect would likely be a physical smothering. This physical smothering and coating effect would be both for the plants and aquatic/semi-aquatic animals, as well as for any animals such as birds or mammals that come into contact with the oil in the marshes.

Q: What are the potential long term impacts of the oil spill on wetlands and will they be able to recover?

Short Answer: The long term- potential for reduced growth and inhibited recovery are a function of the spill intensity, type of oil, concentration of oil, species affected, degree of plant cover, persistence of oil, extent of soil penetration and season of contamination. Due to the difficulty in identifying the specific impacts and the extent of those impacts, it is also difficult to determine the resiliency of these wetlands in being able to recover from oil contamination. Wetlands and marshes are fairly fragile and very biologically active habitats; therefore, the physical effects of fouling and coating of these environments are expected to be significant.
Detailed Answer: Any additional stress from the Deepwater Horizon oil release could be devastating to these resources and serve as a tipping point to the sustainability of the coastal landscape. The Mississippi deltaic plain is experiencing some of the highest historic rates of coastal wetland loss in the country and in the world. Coastal wetland loss has been widespread in Louisiana over the past century and an historic average of 25-30 square miles of land was lost per year from 1978-2000 (Barras *et al.* 2003). Current trends point to an additional loss of approximately 1300 km^2 by 2050. This region experienced yet another spike in wetland loss and degradation as a result of major hurricanes over the last few years. However, the vast expanse of the existing productive wetland ecosystem still represents a significant regional and national asset. The ecological and associated economic impacts could easily have national ramifications.

Although, the long term impacts on wetlands may not be well documented, the reason being that it is often difficult to separate the effect of oil spill on marsh deterioration from ambient rates of deterioration. What we do know is that the long term- potential for reduced growth and inhibited recovery are a function of the spill intensity, type of oil, concentration of oil, species affected, degree of plant cover, persistence of oil, extent of soil penetration and season of contamination. Oil penetration into the soil/sediments has the potential to cause immediate and long term affects to the wetland and wetland plant species. Wetland plant damage could be realized in reduced stem height, reduced plant density, reduced aboveground biomass and slow vegetative recovery. Slow vegetative recovery can have significant ecological impacts, such as, the impact of increasing the wetlands/marsh vulnerability to erosion and loss. Plant sensitivity and vulnerability to oil contamination can vary. For example, if we compare three common *Spartina spp*. that are found in the Gulf Coast region (*S. patens, S. alterniflora*, and *S. lancifolia*) oil contamination may affect the plants to differing degrees. The shoots of *S. patens* and *S. alterniflora* are not resistant to oil contamination and the rhizomes small and shallow. Oiling of these species can reduce their ability to photosynthesize making them susceptible to mortality. Whereas, *S. lancifolia* impacts maybe less devastating possibly due to larger rhizomes and oil resistant shoots.